LORD LISTER

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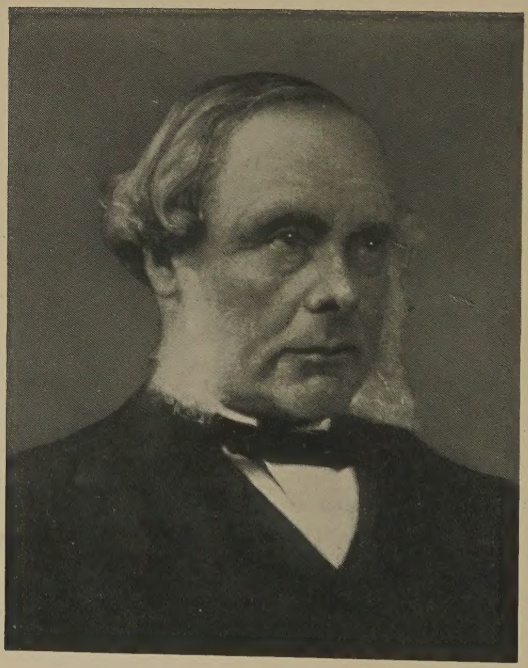

LORD LISTER

THE ROADMAKER SERIES

LORD LISTER

(1827–1912)

By

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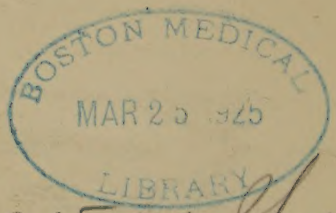

PREFACE

Lord Lister occupies an honourable place amongst the Road Makers of Science: he ranks also as one of the great benefactors of mankind. His indefatigable search for better methods of treating wounds and injuries led him to discover a new principle, the antiseptic system, which enabled him to overcome the grave dangers of septic infection of wounds and opened the way to undreamt-of developments for surgery.

To the medical and scientific world Lister's work is well known, but the wider public, though familiar with his name and most notable discoveries, know little of the difficulties he had to overcome, of the brilliant researches which secured him success, and of the revolution he effected in surgical treatment. This book gives a simple account of Lord Lister's work. For the proper understanding of this and its influence on the practice of the times it has been necessary to discuss the nature of infections and the defensive mechanism of the living cells of the body. To render such technical information easily intelligible to readers untrained in science these questions are discussed in plain language and the vocabulary of pathology avoided as much as possible. The two volumes, "The Collected Papers of Joseph, Baron Lister," have provided

the main source from which information as to Lister's work has been obtained.

Lord Lister's life was not an eventful one. All his time and energy were devoted to his work, and the tale of his life is the tale of his work. Though unattended by adventure or stirring episodes, Lister's common, everyday existence has a peculiar interest, and his keen and penetrating mind, his modest character and his wholehearted love for truth made his life a story well worth telling. For details as to his parentage, his student days, his various appointments, his happy marriage and the honours which crowned his career the writer is indebted chiefly to the biography of Lord Lister written by his nephew, Sir Rickman Godlee, Bart.

My wife, Dr. Ethel Dukes, has helped me very greatly in writing this book.

CUTHBERT DUKES.

LORD LISTER

CHAPTER I

In spite of its antiquity, which dates back as far as human records, the history of surgery can be divided into two periods only: the pre-Listerian era and the modern era. It has been a common occurrence in the experience of the world for a science to make but slow progress beyond a certain point until some discovery, often made outside the realm of that particular science, has been applied to its use, with the result that a few years have seen developments undreamt of during the preceding centuries. Such an example is that of the application of the energy produced by steam to the science of engineering. Equally important, and probably of greater benefit to mankind, was the invention by Lister of the Antiseptic System of Surgery, following upon his acceptance of the discoveries and teaching of Pasteur as to the bacteriological origin of putrefaction. Pasteur's early work had no connection with medicine or surgery; he was a chemist occupied with the problems of the nature of fermentation. In the case of surgery the times were propitious for revolutionary changes, and seldom have the man and the task been brought

together under such favourable circumstances as when Lister's attention was drawn in his student days to the terrible mortality in surgical cases, due not to inferior skill, but to the secondary intervention of foul disease in wounds that might otherwise have healed without any untoward event.

Surgery had been practised in all the older civilisations with varying degrees of refinement and success. During the vigorous period of Indo-Aryan progress it reached a high standard at an early date, for the Hindu writings contain minute instructions for operations of considerable dexterity, together with descriptions of more than one hundred instruments, many of which were similar to those in use in modern surgery. Bandaging, the use of splints, and after-treatment were on the same principles as in more recent times, whilst diagnosis was made upon the recognition of the same symptoms and signs as to-day. The Egyptians and the Greeks developed systems that were equally advanced. The Chinese were much behind the above-mentioned races, for two reasons. One was their respect for the dead; the other was their unwillingness to draw blood or to interfere with the course of nature. Their anatomical beliefs were chiefly imaginary, and their surgery consisted principally of external applications such as poultices and plasters. During the Alexandrian period great advances were made in the study of human anatomy, in diagnostic precision, and in operative procedure. Apparently surgery was in a very flourishing state throughout the whole of the

Roman Empire. The Arabs contributed nothing new to the science of surgery, but they preserved intact for us the teaching of the old world. During mediæval times surgery suffered an eclipse, and the practice both of medicine and surgery fell into the hands of the religious orders. This was forbidden by the Council of Tours in 1163. No notable advances were made in those days: the surgical writings in use were those of the Arabian or classical authors. It was not until the arrival of Paracelsus (1493–1541) and Ambrose Paré (1510–1591) that the monotony of traditional teaching was broken by contributions of originality and genius. In the sixteenth century surgery began to regain some of the brilliance of the art as practised by the ancients. New weapons of warfare had been devised and surgeons had to seek means of treatment for the hitherto unknown forms of injuries. The seventeenth and eighteenth centuries were notable for progress in the teaching of Anatomy, Physiology and Pathology, for the formation of a more complete system of medicine and for the elevation of surgery on to a more scientific basis. The old order of barber surgeons and unqualified practitioners gradually disappeared and the surgeon commenced to receive a scientific education and to rank with the higher order of physicians.

Owing to this advance in scientific teaching, the early part of the nineteenth century saw considerable improvements in mechanical technique and dexterity. Many procedures of classical times were revived and new instruments and operations were invented. About the middle of

the century operations had been rendered *painless*, through the introduction of anæsthetics by Sir James Young Simpson and others. This had made possible still further progress, for no longer was rapidity of performance so essential. The work to which Lister devoted his whole life was to make surgery *safe*. Thus it was that his labours flung a dividing line across the world's history of surgery. It had not been of great help to suffering humanity to have operations made painless if they were still to be as risky as ever. Little does the layman realise that as late as 1865, the year when Lister first introduced his antiseptic methods, the majority of the serious operations which are now performed in their thousands daily with marvellous success, were unknown. Of the remainder, all were beset with danger except those for injuries where the skin was unbroken and remained unbroken as in non-lacerated fractures. Fortunate conclusions could not confidently be expected even in healthy subjects under the most favourable conditions. Sir John Erichsen, a former teacher of Lister's, in a public address in the mid-'seventies, said that operative surgery had at that time reached finality. There were regions in the human body into which the surgeon's knife could never penetrate—the brain, the chest, and the abdomen. How untrue was this forecast a morning in a modern operating theatre would quickly reveal. At the close of Lister's life it was true to say that the exploration of "all those secret chambers of the House of Life have been made possible by the work of Lister. And that work will continue to make practicable

further extensions to a degree we can only surmise. Vast as is the range of modern surgery, it may be said, with D. G. Rosetti, 'Leagues beyond these leagues there is more sea'" (*B.M.J.*, Feb. 24, 1912).

In these times an operation is a commonplace occurrence, and the percentage of the population who escape the surgeon's knife is yearly diminishing. Before the days of Lister surgical treatment of disease was rarely possible, and the patient who now lives healthily and happily through the latter half of his life minus some portion of his anatomy would then have been allowed to die of his disease. Which, perhaps, was just as well; for had the offending tumour been removed, or the amputation performed, a greater danger still remained to be faced. Would the patient recover, or would he succumb to one or more of the septic diseases following the suppuration which was extremely likely to occur in the wound made by the surgeon? This suppuration was looked upon as a normal sequel, and was spoken of as "laudable pus." If these were the results of the clean incisions of the surgeon's knife, how much more likely were they to follow in wounds already dirty owing to battles, accidents or diseases! Many poignant descriptions of the sufferings of wounded soldiers are to be found in ancient writings. The infection of the blood stream from the suppurating wound led to a high fever which drained the strength of the patient, so that gradually his tissues became less capable of resisting the advance of these terrible diseases. In some cases the end came early and suddenly. In

others, the patient sank exhausted, emaciated, and putrid, after a severe struggle with enemies too skilful for the surgeon to outwit, enemies he could not understand, for they were dark, mysterious forces which worked secretly and were all-pervading. When a surgeon had performed successfully the simplest operation, such as an amputation of a portion of a finger, he knew that it might be followed by dangerous and even fatal consequences. Volkmann, the famous professor of surgery in Halle, said that the surgeon when he closed the wound "was like a husbandman who, having sown his field, waits with resignation for what the harvest may bring, and reaps it, fully conscious of his own impotence against the elemental powers which may pour down on him rain, hurricane and hailstorm." We are now aware that the cause of all these catastrophes was sepsis or inflammation caused by the entrance of microbes into the wound and subsequently into the blood stream and healthy tissues of the patient's body. Many factors had been blamed by varying schools of thought at different periods of history, and many methods had been devised to overcome such infections, but in vain. From time to time certain substances which were found to discourage the suppuration were used empirically: each had its fashion and saw the end of its day. Such remedies failed because the laws which governed the formation of pus had never been discovered, and, therefore, there were no known principles upon which to found a school of antisepsis. It remained for Pasteur to discover these laws and for Lister to

apply this knowledge and formulate the necessary principles.

Fatalities due to sepsis were common enough following upon operations in private houses, but the results were far worse when the patient was treated in hospital. This, to us, is a surprising fact, for nowadays the hospital and the nursing home, with its operating theatres modelled upon hospital lines, are well known to be the safest places for operations. And, apparently, there was every reason then why hospitals should have been safer than the homes of a large percentage of the population. Although the influence of Florence Nightingale was not universally felt, the large hospitals were remodelling their nursing arrangements according to her teaching. Surgery had improved considerably and there were many remarkably skilful surgeons in Europe. Since the commencement of the eighteenth century the number of hospitals had greatly increased, so that even relatively small towns possessed one. Compared with earlier institutions, the hospitals of 1865 were large, well-equipped and well-managed, hygienic buildings. Philanthropy was in the air and money for every worthy purpose was contributed generously. Yet the results were deplorably worse than in the days when surgery was inferior and nursing not to be compared with standards then prevalent, when hospitals were small, unhygienic, and grossly overcrowded. It was also noticed that some hospitals were not so heavily visited by the pestilential scourge as others, notably those in the country where surgical cases were few and far between.

The diseases which followed wounds and surgical treatment were small in number; the ravages they caused were illimitable. Hospitalism was the name given to them by Sir James Young Simpson, because they seemed to be as much a part of the hospital as the very stones of which it was built.

The following are the chief diseases included under that name:—

Erysipelas (or St. Antony's Fire).—This was an acute inflammation of the skin due to infection by a microbe now known as the Streptococcus. The skin became red, hot, hard and thickened; later the disease spread to the tissues underneath the skin, and pus was often formed, which buried deep amongst the muscles, perhaps invading the whole limb. High temperature and rigors, or shivering fits, accompanied the illness. There might follow inflammation of the membranes round the heart or lungs, or inflammation of the membranes of the brain. This was always a dangerous and often fatal disease. In a well-regulated hospital this disease is now practically unknown after operations.

Hospital Gangrene.—This was a process of mortification which attacked the wound and the surrounding tissues. Many forms of this disease were known. According to Lister's account there first appeared in the wound a moist grey slough, one-eighth of an inch, or more, in thickness, surrounded by an angry-looking blush. The slough spread amongst the tissues, often rapidly, devouring the limb as it progressed; since the cautery or caustics failed to arrest it,

amputation was the patient's only hope. Even that was not a certain cure, for the infection might reappear in the new wound. When the gangrene reached the upper portions of the limb, or the vital parts of the body, it was fatal. This infection occurred in epidemics in most hospitals; even the best-managed did not escape, whilst in the worst it was always present. To the operating surgeon it was a ghastly nightmare.

Pyæmia.—So named because it was thought that the pus itself passed into the blood. Septic clots formed in the veins were carried by the blood to other parts of the body, such as the joints, kidneys, lungs, liver and peritoneum, where secondary abscesses developed. It began with rigors or shivering fits and high temperature. Death followed from exhaustion after continual suppuration in different portions of the body, or from abscesses in vital organs such as the heart or brain, or from peritonitis. This disease is now so rare that a student may pass through the whole of his training without seeing a single case.

Septicæmia.—Commonly known as blood-poisoning, is an acute infective disease where the germs enter from the wound into the general circulation, and can be found in the blood. It may be caused by many microbes, the most common of which are the streptococcus and the staphylococcus. These are carried by the blood to various parts of the body, where the microbes multiply. The patient may die suddenly or after a long, exhausting illness. Although this disease has not been banished altogether, owing to the

fact that the microbes causing it may already be present in some portion of the body, or may find entrance from boils, stings, wounds, etc., it very rarely occurs as a direct result of surgical treatment.

Tetanus (or Lockjaw).—This is a disease caused by the Tetanus Bacillus, which lives in the soil, and may enter the body through a wound or abrasion. The patient is seized with violent muscular contractions. It is a very painful and exhausting disease. Often the patient cannot eat, because the muscles of the jaw are contracted, spasms of the muscles of the chest prevent his breathing properly, and he may sink exhausted or die from suffocation. The terrible feature of this disease is that the sufferings of the patient are intensified by the fact that while these painful contractions are taking place his brain remains as clear as ever. The microbes remain in the wound and manufacture a powerful toxin which is disseminated through the body. This disease occurred in epidemics in pre-Listerian days: to-day it never occurs as a result of a surgical incision through unbroken skin, and never as an epidemic in hospitals. Patients who develop it after injuries are now treated with success by anti-tetanus serum.

Sir James Young Simpson, in his paper on "Hospitalism," said: "In hospitalising men we decrease their health-rate and increase their death-rate, even though the men thus hospitalised are comparatively in a state of good corporeal or physical health." . . . "The man laid on an operating table in one of our surgical hospitals

is exposed to more chances of death than the English soldier on the field of Waterloo." In the English and Scotch metropolitan hospitals the mortality after operations for amputations of the limbs had risen to a figure higher than one in three. A report, drawn up from the Government official archives, showed that in the year 1861 the death-rate after major operations for amputation of the limbs in all the Parisian hospitals taken as a whole was as high as three deaths out of every five operations. At Belfast in 1867, Sir James Young Simpson, when addressing the Public Health section of the National Association for the Promotion of Social Science, asked the questions, "To what extent are hospitals, as in general at present constituted, banes or blessings? And how can they be changed so as to convert them from the former to the latter?" He suggested that "the stone and marble palaces" should be abandoned, and that iron or wooden villages should be built on the cottage system, which could be taken down every few years and re-erected in different places where the air was free from pollution. To prevent wholesale contagion the patients should be segregated into small groups of twos and threes. In 1874 Sir John Erichsen suggested that hospitals should be periodically razed to the ground. He said: "Once a hospital has become incurably pyæmia-stricken it is as impossible to disinfect it by any known means as it would be to 'disinfect' a crumbling wall of the ants that have taken possession of it, or an old cheese of the maggots that have been generated

in it." And, in truth, the matter was very pressing. For not only were some or all of the diseases which constituted hospitalism present in a hospital at all times of the year, but at certain seasons they became epidemic. Then from patient to patient, from ward to ward, there spread the terrible scourge; even the strongest could not survive. The air was thickly tainted with the smell of the discharges from sores and ulcers; the bodies of the patients rotted away with the encroachment of the foul disease; and nothing remained but to bury the dead and close the wards for the time being until the air could once more become purified.

John Bell in his "Principles of Surgery" (1801) said of Hospital Gangrene, "When it rages in a great hospital it is like a plague: few who are seized with it can escape. There is no hospital, however small, airy, or well regulated, where the epidemic ulcer is not to be found at times; and then no operation dare be performed! Every case stands still! Every wound becomes a sore, and every sore is apt to run into gangrene. It has been named the Hospital Gangrene, and such were its ravages in the Hôtel Dieu of Paris (that great store-house of corruption and disease) that the surgeons did not dare to call it by its true name; they called it the rottenness, foulness, sloughing of the sore! The word hospital gangrene they durst not pronounce, for it sounded like a death-knell; at the hearing of that ominous word the patients gave themselves up for lost." What then, the same author asks, is the surgeon to do? "Is he to try experiments with oint-

ments and plasters, while men are dying around him? Is he to expend butts of wine, contending, as it were, against the elements? No! Let him bear this always in mind, that no dressings have ever been found to stop this ulcer; that no quantities of wine or bark which a man can bear have ever retarded this gangrene; let him bear in mind that this is a hospital disease, that without the circle of the infected walls the men are safe; let him therefore hurry them out from this house of death; let him change the wards; let him take possession of some empty house and so carry his patients into good air; let him lay them in a schoolroom, a church, a dunghill, or in a stable; let him carry them anywhere but to their graves."

Another disease, not connected with general surgery, was responsible for fearful mortality; this was Puerperal Fever, which attacked the lying-in mother after the birth of her child. Puerperal fever is a form of septicæmia, and is due to the activities of those microbes which are responsible for septicæmia. As with all the hospital diseases, it was much more prevalent in the lying-in hospitals than amongst those women who were confined in their own homes, and under certain conditions it became epidemic, sending to their graves thousands of women who might otherwise have lived to old age. Owing to the prevention of sepsis in ordinary midwifery practice it is now fortunately a very rare disease.

The heart-breaking aspect of these diseases was the demoniacal cruelty of their interference

with the normal course of recovery. The surgeon performed a brilliant operation which should have brought to him the glow of honest pride in work well accomplished. Instead of a wholesome scar healing by "first intention," a restored limb and a happy patient, he saw his efforts frustrated and his patient become a mass of corruption. The healthy young mother gave birth to a fine, lusty infant and all was well; yet just when mother and child were out of danger from the struggles of childbirth, along came the insidious infection. In a few hours or days, attended with intense suffering, or perhaps after weeks of protracted illness, there remained but a poisoned corpse and a motherless babe. The superstitious saw in it the work of the Evil Spirits; the religious said it was the Will of God; the sceptics believed it to be only natural forces working their will upon helpless humanity; but all good and honest surgeons, of whatever creed or nationality, longed for the time when such evils should be unknown.

. . . . . .

The patient of to-day who is suffering from a surgical disease, now enters a hospital or nursing home with the assurance that not only will his trouble be removed, but that no other disease is likely to supervene during his convalescence, and that his recovery is as certain as most things can be in this world. He undergoes a serious operation performed by a skilful surgeon of wide experience, whose training has been long and arduous, in a large, clean, well-lighted theatre, where neither expense nor ingenuity has been spared

to ensure strict asepsis. He is nursed by women schooled to the point of perfection in the performance of those duties upon which so much of the continued success of the surgeon's work depends, women whose conscientious attention to the minutest detail and whose unsparing devotion to their patient's welfare in his helplessness and pain can never be imagined by those who have not experienced such attention. In a week or ten days the stitches are taken out of the wound and there is nothing but a thin, red line to show where the incision into the interior of the body had been made. No inflammation, no pus, no temperature! In less than three weeks the patient may be walking about, and very gradually the thin, red line changes into a thin, white line of scar tissue, hardly perceptible as the months pass by. That is all there is to show that human hands have been at work, tampering with the vital organs in a way unknown in the whole experience of mankind until Lister came to show the way.

. . . . . .

That is why the work of Lister is considered to be the dividing line between the two great periods of surgical history; the one great in length of time, the other great in achievement.

CHAPTER II

It is customary for small children to announce their intentions as to the choice of a future occupation, and Lister, being no exception, very early in life told his parents that he wished to become a surgeon. Whether he had earlier loves or whether he changed his mind from time to time history does not tell us. No doubt he had the usual aspirations towards the life of a lamplighter, and, engine drivers not being so much in evidence in his childhood, towards that of a coachman. As he grew older this desire for a scientific career took serious hold upon him, for we are told that he began to dissect animals and articulate their skeletons whilst he was still a young schoolboy. When he was about the age of fifteen or sixteen, amongst other essays, he wrote four papers dealing with "The Human Structure—Osteology," and one on "The Similarity of Structure between a Monkey and a Man." These were beautifully illustrated with pen and wash drawings. He also prepared a lecture on Chemistry in which he dealt with the properties of laughing gas. It is interesting to speculate as to whence came Lister's desires and talents in this direction. No Lister had ever taken up a professional career, and there was no

doctor in the family. The Listers were originally simple country people. Perhaps in him were intensified those scientific tendencies which manifested themselves in his father, Joseph Jackson Lister, who gave his leisure time to microscopic studies and gained a world-wide reputation for his discoveries in the field of Optics. It was these discoveries that led to the production of the "Achromatic Lens," and the perfection of the modern microscope. Those who are interested and wish to learn more of the work of this remarkable self-taught man of business, who in his evenings accomplished more than many whose profession it was to be a scientist, should read Lister's beautiful tribute to his father in a paper which he contributed as an Obituary Notice to the Royal Microscopical Society in 1870. This paper is to be found in "The Collected Papers of Lord Lister."

The Listers originally belonged to Bingley in Yorkshire, and there was one Thomas Lister, maltster and farmer, who married, in 1705, Hannah Lister, daughter of a yeoman and became the great, great-grandfather of Lord Lister. These two joined the Society of Friends and founded a family which remained Quaker for generations, a family which could not help but rise in the world eventually. Plainness and sobriety of living, earnestness of purpose, and the meticulous employment of spare time in worthy pursuits, together with a complete withdrawal from participation in what were regarded as worldly and wicked amusements, enabled its members to prosper not only in business, but also

in the development of those artistic accomplishments and mental attainments which distinguish the cultivated from the ignorant. The eldest son of this maltster-farmer left Yorkshire for London about 1720 and became a tobacconist in Aldersgate Street. His youngest son, John, born in 1737, was first apprenticed as a watchmaker in Bell Alley, Lombard Street. Later he joined his father as a tobacconist, and afterwards entered the business of his father-in-law, Stephen Jackson, who was a wine merchant in Lothbury. John Lister was a citizen of London and a Freeman of the Bakers' Company, and he lived to be ninety-eight. He had two daughters within three years of marriage, and then, after nineteen years' interval, an only son, Joseph Jackson Lister, the father of Lord Lister. This small boy, born into a family of adults, was early made to realise the seriousness of life and the necessity for employing his time well. His father was anxious to give him a good education. He particularly desired that he should have a good knowledge of French and Latin, and although he was permitted to learn drawing because he possessed an obvious talent for it, his parents were inclined to look upon it as an amusement rather than a source of instruction. At the age of seven he was able to write a letter to his parents in French "with only two words corrected by the usher." In a very solemn letter written to him when ten years old his father tells him that he is sending nine books for his instruction and benefit, desires him to discharge well his duties to his instructors and to keep a conscience void of

offence to his Creator; he reprimands him for his slowness in writing and spelling, and mentions the sorrow that his habit of wasting time causes his father. The postscript at the end of the letter probably had more effect in persuading the little fellow to mend his ways than all his father's weighty sentences: "We had intended to have sent thee a plumb cake had we heard a better account, but shall now leave it till another time."

Apparently Joseph Jackson Lister made better use of his opportunities, for at the age of fourteen and a half he left school well grounded in the subjects he had studied and having so much knowledge of Latin to build upon that later on in life he was able to read, with great pleasure to himself, the best Latin authors. On leaving school he was apprenticed to the wine trade, in which his father was engaged. His father's business by this time had become very prosperous, and in it the son progressed so well that at the age of twenty-two he was able to manage the affairs of the concern all alone in his father's absences. He was sent by his father on journeys connected with the business to various parts of the country; and when in Yorkshire he occasionally visited the school at Ackworth which had been established for the education of young Quakers whose parents were in necessitous circumstances. Here he met and fell in love with Isabella Harris, aged twenty-two years, who afterwards became his wife and the mother of Lord Lister. They were married in 1818. She was the daughter of Mrs. Harris, the superintendent of the school, a widow with six children, whose husband, Anthony

Harris, had been a master mariner of Maryport, an opponent of negro slavery and one of the earliest pledged teetotallers. For three generations back his ancestors had traded with Ireland. This was a marriage of which the parents on both sides could not but approve. Judging from a drawing executed by Joseph Jackson Lister in 1821, Lord Lister's mother appears to have been a beautiful woman, with fine, regular features and kindly expression; as a teacher at the school in Ackworth she was noted for her elocutionary powers and for the gentle and winning goodness of her character.

For three years after their marriage the parents of Lord Lister lived at their business premises in Tokenhouse Yard, afterwards moving with their little family to Stoke Newington, where they remained three years. In 1826 they took Upton House, an old Queen Anne residence with fields and gardens, in what was then the tiny country hamlet of Upton in Essex. Not far away were settled other prosperous families of the Quaker persuasion, all of whom attended the Meeting House at Plaistow, where there was to be found a large and interesting circle of Friends, including Elizabeth Fry. In those days the characteristic peculiarities of the sect were still preserved, so that in many ways the world into which Lord Lister was born was a very narrow one. It may have been that this narrowness was the very element needed to foster those talents with which he was born and to encourage such characteristics as enabled him in later years to follow his purpose in life with the singleness of

aim, the minute attention to detail, and the great devotion without which he would never have attained the end he sought. The Friends were very largely cut off from the world in general except in matters of business. They refused to take any kind of oath or to subscribe to the Thirty-nine Articles, therefore they could not be admitted to Oxford or Cambridge Universities. The same reasons kept them from most of the professions except that of medicine, which few entered. As they held pacifist views, they could not take up careers in the Army or Navy. The pleasures of the theatre, dancing, music, hunting and other pastimes were forbidden. The Quaker costume was still worn, which alone was sufficient to distinguish them from the remainder of the world, and they still thee'd and thou'd each other and used the "plain language." The Quakers addressed each other as Friend; even the scullery maid was "Friend." Freedom from the distractions of the world at large and a desire to employ seriously every moment of their leisure time led many Quakers into paths of education, science and philanthropy. It was quite common to find in a man who served in his own shop a richly cultivated mind, often an authority on some science or art.

It was into such a world that Joseph Lister, the fourth child and second son of his parents, was born on April 5, 1827. His immediate environment was a happy and favourable one. Although he and his brothers and sisters, from their earliest days, were impressed with the idea that life was a solemn responsibility, a gift to be employed for

God and in the service of their fellow-creatures, they nevertheless had a wholesome and enjoyable existence. The parents saw to it that they had plenty of fun. Perhaps John Jackson Lister had recollections of a somewhat lonely infancy spent in the company of his middle-aged parents and grown-up sisters. His children had enjoyment in abundance: riding, games, country walks, skating, and parties to which their friends were invited. But, like true Quakers, they taught their children to be serious even in their pleasures, and sought to combine instruction with amusement. The small Listers studied natural history on their walks, and made collections of fossils and other natural objects; as they grew older they read the Latin authors with their father while he was dressing. In spite of his scientific yearnings, Joseph, who was bright and intelligent beyond his age, did best in classics. He was educated at two private schools, one at Hitchen and the other at Grove House, Tottenham, where he acquitted himself well and grew up to be the ordinary, happy, healthy schoolboy. At first his father, having a bias against the idea of surgical interference with Nature, did not encourage him in his notion of becoming a surgeon, but as the boy's tendencies showed themselves more insistently, he decided to put no obstacle in the way.

When he was seventeen years of age Lister left school. In the spring of 1844 he entered University College, London, a non-sectarian institution and a suitable place for one who could not subscribe to the tests of the older Universities.

His father, being desirous that his son should have a good general education before commencing the study of Medicine, encouraged him to take the Arts course first. Lister did so, and in 1847 he graduated as Bachelor of Arts. When he entered the Medical School he came under the influence of brilliant men who were eminent in their profession, and who exerted upon him an influence that lasted throughout his life. University College was modern and expressive of the desire growing up in men's minds at that time for freedom from ancient shackles. Its hospital and medical school were up to date, though smaller than Guy's or St. Bartholomew's. Lister came to know the hospital staff right from the beginning of his career, for in those days there was no sharp line of demarcation between the scientific studies and those connected with the medical side of the students' education, and the students entered the wards in their first year. Two men to whom Lister owed much were Wharton Jones, Professor of Ophthalmic Surgery, and William Sharpey, Professor of Physiology. The former had made important discoveries in the science of Physiology, and it was probably from him that Lister gained the idea of studying the circulation and the effects of inflammation on the web of the frog's foot, which piece of research he afterwards pursued with such excellent results. As a student Lister was kind and considerate, but evidently of a retiring nature, not easily making friendships with other students. Perhaps the fact that he lived in lodgings under the tutelage of an older man of narrow religious

views, who was also a member of the Society of Friends, caused him to restrict his friendship to those of a like persuasion. He was a hard worker, and we are told that he had a precise and rather laborious way of acquiring knowledge; but, thanks to a remarkably accurate memory, this knowledge, once acquired, became a life-long possession. He set to work in a practical manner to prove facts for himself, not being content to accept passively even the most sacred of traditional beliefs—the true Quaker spirit. Even as a student he was busy on research work, seeking for the truth. He gained many honours. Not for him were the ordinary pleasures, much less the dissipations, of the average medical student, who cuts a class with as little concern as he would show when refusing another piece of toast at breakfast. His solemn tutor said of him, "He excels anyone I know or have known in bright promise for the future." And, indeed, for Joseph Lister in those days, life was an undertaking that could not be treated lightly in any phase or aspect. Having by birth and upbringing inherited traditions of seriousness he was not helped towards the usual optimistic cheerfulness of youth by the environment in which he lived. He worked so hard that in 1848 he was compelled to take a long holiday after a severe nervous breakdown which interfered with his studies for some months. He suffered from melancholy, depression and a state of introspection which made him extremely miserable. This passed away, he once more took up his work, and he ended his

career by carrying off the M.B. degree with Honours, thereby placing University College Hospital second in the list of London Schools of Medicine for the year 1849–50, Guy's coming in first. Had Lister been content to confine himself solely to work required for the examinations, it is probable that his school would have headed the list. The fact that the examiner thought it necessary to write in the following manner proves the high opinion he held of Lister's attainments, and will show how far Lister had progressed from the beaten path. It is not usual for examiners to take the trouble of writing letters of explanation to their victims!

"DEAR SIR,

"I fear you will be much disappointed at finding yourself lowest upon the list for Honours which I have to-day sent in to the University; and I think it as well to let you know the reason why I found it requisite to place you there. It was *not* because you expressed, on one or two points, opinions different from those which I have advocated; for I have, before now, recommended for the *scholarship* gentlemen who have done this, with an independence which I am always glad to see; but because, *as answers to my questions*, your papers were so defective, that if it had not been *for the amount of original observation* of which they bore evidence, I could not have placed you in the honours list at all," etc., etc.

A more wholesome existence began for Lister when he entered the hospital as a resident doctor

in 1850, and the brightness he had lost during his cramped life in dismal lodgings came back to him. In 1850 he was house physician to Dr. Walshe, and in 1851 house surgeon to Sir John Erichsen (then plain Mr. Erichsen). It was good for him to live with men who had been brought up in other religious organisations and educated in schools where wider views prevailed. For the first time in his life, at the age of twenty-three, he became closely intimate with men whose ideas were different from his own, under whose influence he lost much of his shyness and took part in the excitement of University and Hospital life. Though his outlook and views broadened, Lister never changed in two respects: to the end of his days he was always known as a man of exquisite moral purity and of deep religious beliefs, which, though they differed as time went on from the narrow ideas of his childhood, were the mainspring of the whole of his existence. He developed a delicate sense of humour which used to shine forth later on when he himself became a lecturer to students. He engaged in University politics, was often in evidence at the Debating Society, and he took an active share in the affairs of the Hospital Medical Society, before which he read two papers, one on "Gangrene," and the other on the "Use of the Microscope in Medicine." These papers indicate the direction in which his mind was working in those days. Lister and his friends formed a brilliant group of young enthusiasts, many of them, later, becoming men of distinction in their profession. His career as a

student came to an end in 1852, when he was made a Fellow of the Royal College of Surgeons after passing the usual examinations. During the latter part of his time he had done some notable original work, which was published in two papers in the *Quarterly Journal of Microscopical Science*. It had no connection with the work which was to occupy all his interest in the future; but it was valuable as an "exercise," besides confirming the work of others and contributing new knowledge to the Sciences of Anatomy and Physiology. The title of the first paper was "Observations on the Contractile Tissue of the Iris"; the second was "Observations on the Muscular Tissue of the Skin." These were microscopical studies made possible by the possession of a wonderfully improved microscope, the gift of his father. In 1853 he also carried out some experimental work of a physiological nature concerning "The Flow of the Lacteal Fluid in the Mesentery of the Mouse," but the results were not published until later. The fertility and originality of Lister's mind are abundantly proved by the fact that, in addition to passing his examinations with Honours in the scheduled time, he found opportunity to conceive and carry out new experiments of such a nature. As a student he was decidedly unusual.

Lister was a fortunate young man. Not only was he free from financial worries, but apparently his father had decided that he should have the best preparation possible for his career as a surgeon. There seemed to be no need for hurry about settling down to earn a living.

During his long studentship of nine years he had travelled much during the vacations in various parts of England, Ireland and the Continent. On these holidays he wrote diaries which show that he was a keen observer and that he had a good knowledge of French and German, with a smattering of Dutch. His style of writing in those early days was stilted and formal, very different from the eloquent language in which the scientific papers of his mature life were produced. Only when he describes natural objects does he become enthusiastic and freer in style, thus showing wherein lay his real interests. In 1853, when he was twenty-six years of age, it was suggested that before settling down as a consulting surgeon in London, he should gain more experience by visiting Edinburgh for a month to see the work of Professor Syme, and by paying a longer visit afterwards to the principal schools of medicine on the Continent. With this plan in his mind he went to Edinburgh in the September of that year, took lodgings in South Frederick Street and presented his introductions to Mr. Syme.

Destiny had other intentions for Joseph Lister, and not until he was fifty years of age did he return to London as a consulting surgeon, many years after the death of his father and when the family home in Essex had long been broken up. Professor Syme seemed to take a liking to him at their first meeting. He made Lister welcome to his home, offered to show him his methods of technique, and gave him work to do both in the Infirmary and in his private practice. At

the outset of a career what a chance! Of all the surgeons in Europe there was perhaps none who could do so much for an earnest, inquiring nature such as Lister's. Lister, on his part, developed an admiration for Syme and his work that never left him. His month in Edinburgh extended into seven years, and the friendship between the two men was never clouded during the remainder of Syme's life. There must have been something attractive about Lister, for Syme was a man with whom many people found it difficult to maintain friendly relations, and the fact that Lister later on became his son-in-law was no reason why such an unclouded friendship should continue to exist. The two were totally different in nature. Lister was reserved, kindly, humorous, a man with a cultured mind, religious and non-combative. We learn that Syme was very outspoken in expressing his confident views about other people and their ideas or methods, nor did he seem to mind whose feelings he hurt in the process. He was a pioneer with a rugged temperament, and though he inspired enthusiasm and had many admirers and supporters, he would not brook opposition from any, even from friends. He possessed an acute and sagacious mind, he was persevering and obstinate, and he seemed to enjoy the medical disputes into which he entered with great pugnacity. When Lister met him, Syme, who was fifty-four years of age, was Professor of Clinical Surgery in the Edinburgh University, and he had a large practice, both private and in the Royal Free Infirmary. He was considered to be the best

and most original surgeon in the British Isles, and he had caused the Chair of Clinical Surgery in Edinburgh to be held in the highest esteem all over the world. When in his younger days the authorities in the Infirmary had refused his application for a surgeoncy, he metaphorically snapped his fingers at them, opened a school of surgery of his own at Minto House, opposite the very gates of the Infirmary, and there introduced a new method of teaching clinical surgery of his own invention. This method was extremely successful, it was later on adopted by Lister, and became the established system of the Edinburgh school, and eventually of other medical colleges. At his home in Morningside, where Syme entertained a great deal, Lister met interesting people of all nationalities, one of the most frequent visitors being Dr. John Brown, author of " Rab and his Friends."

When the month was ended Lister, who thought that he had much more to learn in Edinburgh, decided to remain there during the winter instead of proceeding at once to the Continent. Having visited the city merely to see the practice of Syme, he was astonished to find that the University could boast of a medical school and hospital second to none. There was much wider experience to be obtained here, for while University College Hospital had then only sixty-five surgical beds, the Edinburgh Royal Infirmary had two hundred, whilst all the other departments were equally as advanced. In October he was appointed " supernumerary clerk " to Mr. Syme, a post which did not entail his living in the

hospital. His duties were to assist Mr. Syme in his operations, hand instruments and sponges to him as he needed them, make notes on the cases, and generally take an interest in the patients. There was no responsibility, and the post was below that of a house surgeon. A Fellow of the Royal College of Surgeons, having the credit of two publications to his name, and in those days of limited surgery now fully entitled to the rank of consulting surgeon, might have spurned such a lowly offer. Not so Joseph Lister! He was modest enough to take the lowliest position if only it helped him to enlarge his knowledge. Even during the few weeks when he acted as "supernumerary clerk" he managed to write a surgical paper which he read before a meeting of the Edinburgh Medico-Chirurgical Society, attended by some of the most eminent medical men of the day. It consisted of the description of the "Method of Ossification in an Ex Ostosis (*i.e.* a new bony growth) removed by Mr. Syme from the Os Humeri of a Young Lady." This work was microscopical.

Early in the new year (1854) another stroke of good fortune fell across Lister's path. The Resident House Surgeon who had charge of Professor Syme's beds left, and Lister was asked to take his place, a position he held until February 1855. He was a great success in this post. Apparently Syme had a good opinion of his capabilities, for he rarely interfered with Lister's treatment of the ordinary cases, and, a very rare thing, allowed him to decide as to which of the patients admitted at night he

himself should operate upon. During his house-surgeoncy Lister rendered great service to the medical world and to Syme himself, by sending weekly reports to the *Lancet* of Syme's lectures on Surgery which were delivered in the Royal Infirmary. Had Lister not done this, it is quite likely that much of Syme's very original teaching would have been lost, for he was too busy a man to write books. Lister was much loved by the students who acted under his tuition as dressers for his personality and for the painstaking way in which he taught them all they ought to know. Then, and later on, he was always known as "The Chief" by those who became his followers.

Yet a third stroke of good fortune fell to Lister. Three months before his house-surgeoncy ended, there came news from the Crimean War of the death of Dr. Mackenzie, an Assistant Surgeon to the Infirmary and lecturer on Surgery in the College of Surgeons, the older school of medicine in Edinburgh and rival to the University. He had been looked upon as a man of great promise and the one most likely to be appointed to the Chair of Clinical Surgery when Syme should vacate it. Many saw in Lister a worthy successor to the late Dr. Mackenzie. Accordingly it was suggested that he should continue Mackenzie's lectures in the meantime, and apply for the vacant position of Assistant Surgeon to the Infirmary. Lister was only too eager to do this, for in this opportunity he saw the opening to a promising career which might end some day in the occupancy of the

most important surgical position in the United Kingdom. He consulted Syme, who at first did not encourage the idea, thinking that the young surgeon would do better in London. Later he changed his mind and promised to support Lister in his application for the post. Four months after the news of the death of Dr. Mackenzie had reached Edinburgh, and when Lister had obtained Syme's support and was sure in his own mind that it was the right thing to do, he wrote a very long letter to his father, in which he discussed this opportunity and mentioned his desire to seize it. Modestly he says, " I am encouraged to hope that, though I must not expect to be a Liston or a Syme, still I shall get on. Certain it is that I love Surgery more and more, and this is one great point; and I believe my judgment is pretty sound, which is another most important point. Also I trust I am honest and a lover of truth, which is perhaps as important as anything. As to *brilliant* talent I know I do not possess it; but I must try to make up as far as I can by perseverance."

Although this position would keep Lister far away from home, the parents were willing that he should apply for it, upon which he hired the lecture room at 4, High School Yard that Mackenzie had formerly occupied. At last the young man blossomed forth as a Consulting Surgeon, and experienced all the thrills accompanying such an adventure in life. He took a consulting-room and lodgings at 3, Rutland Street, opposite Professor Syme's consulting-rooms, and just about this time, April, 1855, he was elected a

Fellow of the Edinburgh Royal College of Surgeons. The Continental visit being now impossible, he went to Paris for a month in June to learn something of surgery there, after which he came back to Edinburgh to prepare for the lectures to be given to the students in the autumn. These were exciting months for him, because in addition to the preparation of these lectures and the assistance he was giving to Professor Syme in his practice, he had commenced research work upon a most fascinating subject, one which, with its incidental ramifications, was to occupy all his spare time until he suddenly found what he was looking for in the new discoveries of Pasteur in 1865. This was the study of inflammation. As he had to deal with the subject in his coming lectures, the first task he undertook was to find out what happened in the very early stages of inflammation, being dissatisfied with the accepted theories. He commenced a series of simple but brilliantly conceived experiments on the web of the frog's foot and the wing of the bat, wherein the circulation is clearly demonstrable. So far the theories of inflammation had been based upon what was seen in the later stages after secondary changes had set in. Lister tried to find out what happened at the very first deviation from the normal. The results were astonishing and illuminating, and practically all have stood the test of time.

Then came the great day when Lister, so lately himself a student, stood up to deliver his first lecture on "The Principles and Practice of Surgery" in No. 4, High School Yards. Owing

to the pressure of other work he left the writing of the lecture until the night before it was to be delivered. He slept for half an hour only and worked almost the whole night, finishing the twenty-one pages of which the lecture consisted a few minutes before he was due to commence. This drew from his father a gentle reprimand upon his habit of unpunctuality. "But was it not running too great a risk and *tempting* failure in thy first lecture to delay till so late its preparation? An example of which is to be avoided hereafter." The lecture, however, was apparently a success, and the students "applauded vehemently" when he had finished. He himself realised, as do most public speakers, that a great deal can be said in a short time, and that if he was to keep up a good standard there was much hard work ahead during the winter. Sixty years afterwards Sir John Batty Tuke wrote to Sir William Turner, Principal of Edinburgh University, "I was his first student. . . . He impressed us all deeply from the beginning, both in the wards and the lecture room. . . . He worked us very hard. The general impression was that he was a great thinker, and he was treated as such by all the men."

Lister's first two years in Edinburgh must have been happy ones. To be the favoured protégé of a genius like Syme, to have the benefit of his teaching and advice, the result of an experience of thirty years, to have as much operating as the most ambitious could want, and the prospect of a brilliant future opening out before him, surely this was an enviable existence! And it was, if we are to believe the sentiments

Lister expressed in his letters to his father at that period. Yet his work was not the sole cause of his happiness, nor the promising career ahead. When he decided to prolong his month in Edinburgh there was, perhaps, a subconscious motive of which he was unaware at the time. From the first he had taken an interest in Agnes, the eldest daughter of Mr. Syme. She was attracted by the newcomer of whom her father expected so much in the future. An engagement followed, they were married on April 25, 1856, and thus commenced one of those happy unions—not so uncommon as the pessimists would have us believe. Agnes Syme was eminently fitted to be the wife of a man like Lister. He lived for his work, and any other interests he had were those which arose out of his work, except such holiday occupations as the study of nature, languages, architecture and such like. There was no division of his day into working time and leisure time; work was recreation and recreation was work. The reason for his notorious unpunctuality was that he was always hard at work until the last minute. As with his first lecture, his papers or speeches were usually prepared immediately before a meeting, often during the previous night, and sometimes finished off in a train or a cab! In the woman he loved Lister found an ideal comrade; an ever-unwearied secretary who never complained though her hours of scribbling at his dictation extended all through the night and into the early dawn; a thoughtful, devoted wife who saw to it that he had sufficient rest and comfort to prevent

the exigencies of his work overtaxing his strength, whose bright and happy presence made his home a place of delight; and a hostess who was loved by all who came to know her. Like most Victorian wives, Agnes Lister had no "career" apart from that of her husband. Although she had no artistic accomplishments, she was a good linguist, and she possessed an intelligent and receptive mind, which not only enabled her to acquire a store of interesting knowledge, but there is evidence to prove that she had made her husband's subject her own, so that in moments of hesitation or difficulty she was able to offer helpful suggestions. All the notebooks containing the records of his vast experimental and surgical investigations are in her handwriting. Apart from his work their interests were alike, and they were of the same religious persuasion, for when Lister married and left the Society of Friends he joined the Episcopal Church of Scotland. They had no children. This perfect love match, with its happy comradeship and common ideals, lasted for thirty-seven years, until the death of Lady Lister from pneumonia, which occurred while they were on a holiday in the Italian lakes in 1893.

After the marriage, which took place in the drawing-room of Professor Syme's house "Millbank," according to the Scottish fashion in those days, Lister and his wife spent a month in the English Lakes and at Upton House. Now came the opportunity for the Continental tour which had been planned more than two years earlier. Three months were given to this, during which

time the young couple travelled up the Rhine, saw Brussels and Cologne, had a short holiday in Switzerland, and then visited the most celebrated surgeons and medical schools in Europe. At Pavia they saw in the museum of the medical school the head, forefingers and thumbs of Scarpa, the great Italian surgeon, preserved in spirit, "these being the parts of the body most used in Surgery." Vienna had the largest and most important School of Medicine, and there Lister met Professor Rokitanski, the most eminent pathologist in the world, who had been entertained by Lister's father at Upton House fourteen years earlier. At Leipzic Hospital Lister was interested in the unique method of teaching surgery then followed by the professors and also in something else he had never seen elsewhere. During the last month of the summer session the two house surgeons were always allowed to perform *every* operation, the surgeon only standing by to give advice and assistance, "an arrangement no doubt very advantageous for the young men, but of questionable expediency as regards the interests of the patients." During this tour Lister's surgical experience was greatly augmented. He saw many methods of surgical practice differing from those with which he was familiar, he met and was hospitably entertained by some of the most learned men of the day with whom he was able to exchange ideas, but he learnt little to help him in his quest for the causes of putrefaction.

Lister and his wife returned to Edinburgh in October 1856, and made their first home at

No. 11, Rutland Street. The young man was now twenty-nine, and his education, which was completed by the foreign tour, had been a comprehensive one. But Lister felt himself to be only at the fringe of knowledge, and he immediately set to work upon research, for he was determined to discover the truth concerning inflammation, and he was more anxious than ever that he should be able to give his students something worth having in his lectures. That month he was unanimously elected to the coveted post of Assistant Surgeon to the Infirmary in Dr. Mackenzie's place, and in November he gave his first lecture before the Royal Society of Edinburgh, where he addressed the *élite* of the Scottish medical and scientific world.

Lister now became a very busy man. In February 1857 he operated in public for the first time before the students in the Infirmary operating theatre, which, naturally, was an exciting ordeal for him, but which brought him congratulations from the surgeons and old practitioners who were present to watch his début and much cheering from the students. This year also he found that he had the beginnings of a private practice, and as the year went on Syme entrusted more and more of his work to him, perhaps because he was anxious that his son-in-law should gain as much experience as possible and have the chance of showing what was in him. His class at the College of Surgeons was small, but enthusiastic. So happy was he that in a letter to his mother he spoke of " fearing, as I am sometimes apt to do, that a mode of life

so much in accordance with my taste as mine now is must be too pleasant to be proper for me." As his scientific research progressed he found it gave him great help in the practical part of surgery and in the surgical physiology and pathology which he increasingly taught to the students. He even managed to persuade them to come to a *voluntary* class in the summer months for instruction in courses not prescribed in the official curriculum! He continued to be Assistant Surgeon to the Infirmary until the year 1860, and during these years he established a name for himself as a clever surgeon of unusual ability, a great and original thinker and a scientific worker whose only aim was the search for truth. His research work was valued, not only in the United Kingdom, but by scientists everywhere.

In 1859, when Lister was nearly thirty-three years of age, Dr. Lawrie, the Professor of Surgery in the University of Glasgow, being in failing health, and on the point of retiring, Dr. Allen Thompson, one of the most influential of the other professors, communicated with Mr. Syme, saying that in his opinion and that of the others Lister was considered to be the most suitable man for a successor. This professorship was a "Regius Professorship," that is, the appointment was settled by the Crown. Lister had a good chance with the Ministry then in being because of the influence Professor Allen Thompson and the others had with Lord John Russell and Lord Palmerston. Syme, who personally would have preferred to keep his assistant and friend, not to mention his daughter, in

Edinburgh, was willing to do all he could to help by his influence. There were others, also, who were ready to help. Although Lister felt regret at the thought of leaving Edinburgh, where he had been so happy, he had five reasons for thinking he ought to go. Firstly, the salary was not to be despised; secondly, the office would bring him extensive private practice if he chose to avail himself of such opportunities; thirdly, there was a promise attached that he should be appointed, in addition, one of the Surgeons to the Glasgow Infirmary; fourthly, as Professor of Surgery in Glasgow he would have a claim upon the Professorship in Edinburgh when it should become vacant; and, last of all, his chances of success in the application for any appointment in London would be much increased. Lister still had his ambitions fixed upon London. After some delay the appointment was made on January 28, 1860, and when the document arrived announcing that Her Majesty the Queen had approved, Lister was overcome with gladness. He said in a letter to his father the next day that he had "an assurance that if we are permitted to go to Glasgow, we shall be in our right place there."

Glasgow proved to be the right place for Lister, who was in the prime of life and intellectually prepared to take fullest advantage of becoming a professor with wards of his own. He had now a great reputation, sufficient experience to give him confidence with his colleagues, and had he remained under the shadow of Syme it is questionable whether his Antiseptic System

could have been launched as successfully when the time came. The Glasgow School of Medicine was young, having only attained to a full status in the days of Dr. Cullen in 1746. When Lister entered it, the University was in a flourishing state and very popular, the circle of professors was a brilliant one, including Sir William Thomson, afterwards Lord Kelvin, the teaching was good and the fees were low, consequently, students were attracted from all parts of the world. So that, for a young professor who wished to introduce to the medical profession a new system of surgery, there could have been no better platform found from which to preach his doctrines. Lister settled down there very happily in May 1860, and commenced at once a course of summer lectures, an innovation in Glasgow. They were well attended, contrary to the anticipations of his colleagues. Having found the lecture theatre in a disreputable state, Lister had it renovated at his own expense, and he also persuaded the Senate to carry out some very rudimentary sanitary improvements. On the opening day of the winter session the theatre was more than full of students, friends, and critics. It is said that as the students came in they seemed very pleased with the improvements; so impressed were they that they even took off their hats and listened to the lecture in silence, behaviour which was most unusual and was freely commented upon. At last the class numbered one hundred and eighty-two, which was probably the largest class of systematic surgery in Europe. The students admired Lister, and he gained stimulus

from such a large and enthusiastic audience. So attentive were they that they forgot to scratch the shining new desks which Lister had provided! He was the third occupant of the Glasgow Chair of Surgery, which was founded in 1815, but he was the first to conduct a purely surgical consulting practice, his predecessors having been doctors with large general practices. In those days those who performed operations only did so as part of their general work. There was not enough surgical work to bring in a decent income or to keep those who specialised in surgery uniformly busy. That Lister was one of the first to encourage the growth of his practice on purely surgical lines was due to the fact that he wished to have as much time as possible for research.

CHAPTER III

"In the field of observation chance only favours the mind which is prepared," said Pasteur. Hence it was that of all men engaged in the pursuit of surgery Lister was perhaps the most ready to understand the importance of the new doctrine of the origin of decomposition in organic substances and to build upon that foundation the System of Antiseptic Surgery.

For the special work which he was to do Lister was exceptionally well endowed, partly by Nature and partly by mental acquisition. He was sincere, single-minded, and very much in earnest. A man of "vision," he had also a wonderful talent for patient investigation into detail, for meeting difficulties without discouragement, for devising means to overcome them, and for inventing apparatus and methods of investigation where none had existed before. He possessed the gift of unusual mental insight, of getting straight to the point, of neglecting unessentials, and he was blessed with much common sense, probably derived from his Yorkshire ancestors. He had a splendid physique and was able to endure much physical and mental effort. In addition to Surgery, he had stored

his mind with a greater knowledge of Chemistry and Physiology than the average medical student acquires. His knowledge of Chemistry was to be of the utmost use to him in the working out of the details of his Antiseptic System. He was also an expert physiologist. From his investigations into the normal behaviour of the tissues of the body he proceeded to study the behaviour of those tissues under the influence of disease, and his contributions to Pathology were considerable. Not only in his research work, which was carried on in spare moments during the day and often throughout the whole night in his laboratory at home, but also in the details of everyday surgical procedure and in the management of his wards, he sought the cause and the cure of the evil which blighted the whole of surgery—suppuration in wounds. He frequently told his students that the man who could explain suppuration and enable an open wound to heal like a closed one would be amongst the greatest benefactors of his age. In 1854 he showed a perfectly healing wound to Sir John Batty Tuke, then a young student, and said, " The main object of my life is to find out how to procure such a result in all wounds." Thus it was that when he read for the first time the conclusions of Pasteur as to the causation of decomposition in organic fluids, it was as if a man groping his way through darkness suddenly perceived the pathway lit up by the dawn.

In addition to the papers mentioned in the last chapter, Lister, while he was a house surgeon

in University College Hospital, had investigated the character of the pus formed in a case of Pyæmia occurring after an operation on the elbow joint of a boy. He studied also an epidemic of gangrene occurring in his wards during the same period. After prolonged microscopic studies he made very careful camera-lucida sketches of the appearance of the tissues in both diseases. Judging by the minute bodies which were to be seen in the pus from the gangrene cases, he formed, even at that early date, an idea that gangrene might be due to a fungus growing in the wound. In Edinburgh and Glasgow his spare time for many years was given up to experiments in his laboratory. He worked at the problems of "The Duration of Vitality in the Tissues of the Body"; "The Minute Structure of Involuntary Muscle Fibre"; the "Cutaneous Pigmentary System of the Frog." He turned his attention to "The Early Stages of Inflammation," upon which he was able to throw a new and illuminating light; to the "Development of Gangrene from Inflammation of the Arteries"; to the "Coagulation of Blood both Within and Without the Blood Vessels." A third series of experiments of a complicated nature were concerned with the "Functions of the Nerves in Regulating the Contraction of Arteries." After he settled in Glasgow he continued his studies on the Coagulation of the Blood. Nor was Lister behind other surgeons in devising improvements in the technique of surgery. Indeed he made many helpful con-

tributions to this branch of his profession; these alone would have made his name famous amongst surgeons. In view of his much more important gift to the world these have largely been lost sight of, but the following may be mentioned. He invented a new operation for excision of the wrist joint, an operation he performed instead of amputation in cases of disease of that joint, thereby preserving the use of the hand; a new method of amputating at the knee joint; a tourniquet for controlling the abdominal aorta; and a new method for bloodless operating. Nothing was beneath his notice. To him we are indebted for a little hook for extracting foreign bodies from the ear, an instrument he devised when there was brought to him a small girl who had pushed into her ear a large iron bead. The papers containing the results of his experiments and inventions were either read before learned societies or published in various medical and scientific journals. By the year 1861 the young surgeon was becoming known to the world at large. He was therefore asked by the publishers to contribute the articles on "Anæsthetics" and "Amputations" for "Holmes' System of Surgery." This publication was a large encyclopædia of surgery, the first of its kind. It was written, not for the medical student, but for the practising surgeon, and contained the latest knowledge and improvements in surgical technique, much of which information could not be found in ordinary text-books. As this work was the most important

of its kind in this country for many years, we can appreciate the honour that was conferred upon Lister when we learn that he was the only surgeon outside London who was asked to write for it.

When Lister had been in Glasgow fifteen months, and had completed more than a whole academical year of lecturing to the students, he was appointed surgeon to the Infirmary, where he assumed charge of the famous wards, where antisepsis was first applied. Until 1924 these wards were still in existence. Glasgow Royal Infirmary was one of the best hospitals in the kingdom; a new part had just been opened and the total accommodation for patients was almost as great as that of St. Bartholomew's, then the largest hospital in London, though considerably smaller than at present.

University College Hospital, where Lister was trained, was much smaller. At that time it contained eighty beds for surgical cases. There was one small theatre in which about 200 operations were performed annually. The operations were carried out on one special day of the week only; on that day all the surgical staff assembled and those not engaged in operating watched or assisted the others.

It is not because of the introduction of anæsthetics, nor that the number of surgical diseases has increased during the age of industry, nor is it owing to the great improvements in methods of diagnosis, including the introduction of *X*-rays, that surgery has expanded so enormously during

the last fifty years. These certainly contributed somewhat to its growth. Scientific advances bestowed benefits upon surgery, as on other activities of mankind. Particularly did the use of anæsthetics favour its development. People no longer preferred to die rather than submit to a necessary operation; the agony had been removed. When all these factors have been taken into account, however, it is easily recognised that the principal obstacle to any great advance in surgery was sepsis; inflammation was sure to follow in any wound made by the surgeon, and as we now know, the cause was the entrance of bacteria. For this reason, only urgent operations were performed. A great part of the human body was never explored by surgeons, most patients being under the care of physicians who treated them according to the opinions they held as to what was happening inside. As a rule operations were not performed upon the head or the spinal column. Occasionally a very daring surgeon would open an abscess of the brain. Such operations were nearly always fatal. Diseases of the chest with but few exceptions were beyond the reach of the surgeon, and such operations as were possible were always regarded as very dangerous. Similarly diseases of the abdominal cavity were left entirely to the care of physicians. Amputations, however, were much more numerous than at the present time, the reason for this being that very little was done in the way of "conservative surgery," or surgery which aims at preserving the use of the injured limb or

organ. In an accident case where the limb was crushed and bleeding, with broken bones, the nerves and blood-vessels severed, and already contaminated with dirt and filth, it was useless to try to preserve the limb. Off it came at the most convenient site for operation above the injury, and even then it was possible that the patient would lose his life through the development of inflammation and pus in the "stump" —that is, the place where the limb had been severed.

The modern surgeon's chances of saving such an injured limb are multiplied a thousand-fold, thanks to Lister's discoveries. Without introducing any bacteria not already there, the surgeon cleans out the wound with suitable aseptic or antiseptic agents, he ties up the ends of the bleeding vessels, and Nature commences at once to organise a new system of vessels by means of collateral branches. He sets the bones and, if necessary, unites them with silver wire or other sutures, he stitches together the large nerves that have been severed, he assists Nature to battle against the sepsis produced by the bacteria which entered the wound with the injury, and he drains away the discharges that are the result of this sepsis. Finally, when all is aseptic, or perfectly clean, he sews up the skin. Later on, if he should find that the bones have not united, or that the functions of the nervous system have not been restored, he opens up the wound again, transplants bone or nerve from other parts of the body, shuts up the wound at

once, and waits in confidence for the joining up of bone to bone and nerve to nerve.

When, in the light of our present knowledge, we examine the methods of surgeons who were practising about the middle of the nineteenth century, we realise how fortunate it was that any wound should ever heal, and occasionally it did, without the presence of inflammation and pus. In spite of the use of anæsthetics many surgeons were still under the impression that speed was of paramount importance, therefore it had not yet occurred to them to introduce innovations in the way of fine technique such as that with which we are familiar to-day. When Lister was a student the operating theatre at University College Hospital was a small room containing merely an instrument cupboard, a wooden table, and a single gas-jet, with one small washing basin. The surgeon, instead of taking off his coat and being apparelled in steam sterilised overalls and cap, as is now the custom, used for his work an old operating coat that lasted for many years without washing which finally was so dirty and stained with blood and other discharges as to present an appearance that must have been alarming. But the owner was proud of it; the worse it became the more did it proclaim to onlookers the wide experience of the surgeon who wore it. The ligatures of to-day are kept in sterilised fluid in sealed bottles until needed; then the surgeon carried the whipcord or silk which he used for tying up the arteries in the pocket of his coat. As the operation proceeded microbes were introduced into the

body of the patient in so many ways and by so many different agents—by the surgeon's hands, his instruments, ligatures and swabs—that when all was finished what, under modern conditions, would have been an aseptic wound, was then unknowingly heavily contaminated with germs. In the wards there were still further dangers to be faced by the patient. The sanitary arrangements were primitive and the closets opened straight into the wards. According to our notions there was a very inadequate supply of hot water for cleansing purposes, and antiseptic fluids were either absent or too weak to be of any use. Since the conception of sepsis being conveyed by nurses and others had not yet dawned upon the medical profession, the well-intentioned ministrations of the nurses often assisted in the spread of disease. When the surgeon paid his visits he often used the same probe for all the patients, neither sterilising nor boiling it between the cases, because he did not understand the danger of conveying infection. Instead of cleaning out the wound with sterilised swabs of cotton wool which could then be burnt, ordinary marine sponges were used and simply washed in soap and water. These sponges must often have been loaded with disease-producing germs absorbed from the wounds. Patients suffering from hospital diseases were kept in beds next to those who were healthy. No wonder that these diseases spread through the wards like the plague! Owing to the presence of foul discharges and gangrene the smell pervading a surgical ward was nauseating

and more trying to the student than the sights of the dissecting-room or operating theatre.

It must not be concluded that surgeons were blameworthy and hospitals carelessly managed. The medical service of that day was painstaking and devoted, and doctors and nurses were activated by the wish to do their best for their patients. But they were in ignorance of the manner in which infection is spread, and they knew nothing of those microscopic foes which are the agents of suppuration in wounds. To the surgeon of those days an operation was a dirty piece of work, and it would have been an extravagance to have provided clean overalls for every operating day. In his visits round the wards a careful surgeon would wash his hands after dressing one wound and before proceeding to the next patient, but he did not know that mere washing with soap and water is insufficient to destroy the living agents of infection. He took less care with his instruments and sponges, and little realised that with these he sowed the seeds of disease in the wounds he sought to heal.

Nor is it just to condemn the hospitals of that day for design and arrangement which to us seem lamentably unhealthy. They were constructed before the great public health movement of the later part of the nineteenth century had exerted its influence on the thoughts and habits of the people. The value of fresh air, sunlight, cleanliness and good sanitation was then but very imperfectly understood : only a small group of reformers proclaimed these as the essentials of

health. Before the introduction of Lister's antiseptic system, however, improvements were being made in the general conduct of hospitals. Younger surgeons took off their coats and operated with turned-up shirt sleeves, to the derision of their older colleagues. Wherever the influence of Florence Nightingale was felt the training of nurses improved, the supply of towels and hot water became more plentiful, and a more hygienic régime was introduced. New hospitals were built on an improved plan, more space being allowed to each patient and a more generous supply of fresh air secured. All these improvements, however, made little difference to the spread of hospital diseases. The ideal for which the hygiene teachers strove was cleanliness, but common cleanliness is insufficient for the surgeon. His ideal must be a loftier one, not merely to do away with dirt that can be seen with the eye, but the avoidance of enemies only visible with the highest magnifications of the microscope. Asepsis, not cleanliness, must be his aim. The difference between asepsis and cleanliness has been well compared to the difference between holiness and respectability.

CHAPTER IV

Some knowledge of the manner in which the cells of the body set to work to repair an injury and of the notions of surgeons in Pre-Listerian days as to how recovery could best be accelerated will give the reader a better understanding of the difficulties with which Lister had to contend and the improvements for which he was responsible.

The thread of the story must therefore be interrupted with a short account of these matters; but readers well informed in pathology, and also such as have little curiosity except concerning Lister's life and character may safely skip the next few pages and resume their reading at Chapter V.

There are two main classes of physical injuries. The first consists of all those injuries, from a mere bruising to a simple fracture, where the skin remains unbroken. However bad the internal damage, all surgeons of the Pre-Listerian era were aware that an injury which did not involve any break in the continuity of the skin healed without sepsis. The second class, known as wounds, consists of injuries where the skin is severed. There are four kinds of wounds, viz.: punctured, incised, lacerated and contused—

terms which explain themselves. The wounds made by a surgeon at the time of operation are generally of the incised variety.

Healing of wounds may take place in various ways. The most satisfactory of these is that known as "Healing by First Intention," and it is the method that Nature invariably follows after an operation or injury which has been kept aseptic from the beginning. It may be studied best in an incised wound made by the surgeon. When the edges of the wound are approximated, a certain amount of blood-clot is formed, which is greater or less according to circumstances, and is spread out between the two surfaces of the wound, filling in the gap. It consists of red and white blood-cells (corpuscles) mixed with a quantity of fibrin, which is a stringy substance that only appears when blood clots. This forms a temporary uniting medium between the two divided surfaces, and is also used as a scaffolding for the support of new tissue. The ends of the severed blood-vessels also become filled with clot in order to prevent further bleeding. The capillaries, which are very small blood-vessels linking up the veins to the arteries, now begin to send out tiny buds and fine processes which grow from the capillary wall and form a firmer but still temporary bridge. These tiny buds grow into fine filaments which join up either with near capillaries or with similar filaments. They then become hollow and are filled with blood from the capillaries that gave them origin. Thus they form new capillary

loops. The spaces between these loops are filled with tiny new cells, called fibro-blasts, somewhat larger than the blood corpuscles, which have a very special work to do. They are generated by the connective tissue in the neighbourhood and by the lining of the new blood-vessels, and their work is to form the bridge which is going to be the final uniting medium of the wound. If there is any foreign body, such as a stitch (suture) in the wound, other cells known as giant cells appear. Their work is to surround the foreign body, and where the suture is made of catgut they devour it. Wandering leucocytes (or white cells) may also be found in the spaces between the capillary loops. They come from the blood, and their function is to eat up the red corpuscles and fibrin of the original blood-clot. Having done this, they either pass back into the circulation, or in their turn share a cannibal fate. The young capillary loops with their supporting cells and fluids constitute granulation tissue, and this is the basis of all repair in any part of the body. The appearances described are those seen under the microscope. To the naked eye granulation tissue appears as a soft, red, jelly-like mass, and may be seen in a wide-open wound where there is no sepsis. It soon begins to change into young cicatricial or scar tissue. The fibroblasts grow much larger, rounder, and finally become spindle-shaped, and form around themselves a substance which gradually develops into white fibrous tissue, a tissue that is very strong and dense.

This tissue arranges itself according to the pull or pressure put upon the part by the opposing surfaces of the wound, while the capillaries become much narrower in calibre and less in number. All this time the skin has not been inactive. Some of the cells of the skin close to the edge of the wound begin to sprout and spread over the surface of the granulation tissue, gradually forming as they grow a very thin pink film. As this film thickens it assumes a bluish hue, and later on, as its cells become hardened, a greyish white. True epithelium is thus formed over the scar tissue, which is now protected in the same way as the remainder of the body and the wound is completely closed. In parts of the body where the blood supply is unusually plentiful, such as the face, these stages of repair take three to five days; in other parts, such as the limbs or the trunk, from a week to ten days are needed. In the course of time, the cells and the blood-vessels become smaller still, the young scar tissue shrinks until it forms a firm connection between one portion of the wound and the other, and at last is stronger than the tissues which it unites. On the surface of the body is a thin white line known as a scar, which may remain there for the remainder of the patient's life. In young children, in whom growth is very active, the scar may be replaced eventually by the ordinary cells of the body, and there is nothing to show where a wound has been inflicted. Small portions of the anatomy, such as the end of a finger, or the tip of the nose,

have been known occasionally to adhere by " first intention " after being accurately replaced and fixed in position. In healing by " First Intention " there is no infection by microbes, therefore the general health of the patient is unaffected. The temperature is not raised and the functions of the body are not disturbed: the surface of the body surrounding the wound is cool, of a natural colour, and free from pain.

A second method, known as " Healing by Granulation," occurs in wounds that are wide and gaping. It is in no way different from the first, except that the wound is gradually filled in from the bottom with granulations, which look like a velvety red carpet. In time a scar forms which is depressed below the surrounding skin.

A third way is " Healing under a Scab." This occurs sometimes in small superficial wounds. The dried blood and serum on the surface of the wound forms a crust or scab, which is Nature's method of providing an aseptic pad or dressing. Underneath this crust, which excludes the air and microbes, healing takes place by first intention, and eventually the scab falls off, revealing the scar that has formed underneath.

Healing by Inflammation has next to be considered. Inflammation is the reaction of the body to an irritant which may be mechanical, thermal, chemical, or due to want of rest in the injured part, or caused by the presence of microbes. The last is the most serious irritant. In the other forms the irritant is merely local, it does not

spread, and as long as it does not destroy the affected area ideal repair can take place. But the irritation caused by bacterial invasion is cumulative. The damaged tissues are rich in the food that bacteria thrive upon; like emigrants transported to a new and favourable country, their development is stimulated to a greater degree than before. Toxins or poisonous substances are produced, which increase the irritation, and both germs and toxins may quickly pass to other parts of the body. Heat, redness, pain, swelling, and loss of function may accompany inflammation. If bacterial infection exists one or more of the following may complicate the injury: the formation of pus, fever, loss of appetite, sweating, rigors (or shivering fits), and changes in the functions of the body. In most spreading infections the number of white corpuscles in the blood-stream is greatly increased; it is they who fight the bacteria.

After invasion of a wound by pathogenic bacteria the struggle commences immediately. The bacteria multiply and live on the damaged tissues. In so doing they manufacture poisonous substances which damage the surrounding regions. Body-cells nearest to the bacteria may be killed at once: those a little further away damaged, and of these some, being unable to recuperate, eventually die. Cells that are still further away are only irritated, and these cells take on an increased activity. They begin to grow and perform all their functions more rapidly than normally. The bone marrow of the long bones, and other

strategic reserves, having received a message that more white corpuscles are needed, set to work at once to increase the supply of these fighting units, and the blood, which normally contains an average of 7,500 leucocytes per cubic millimetre, may now contain as many as 20,000 or even 40,000. The blood vessels in the neighbourhood of the wound dilate, and more blood arrives on the scene. Large numbers of leucocytes, or white corpuscles, escape from the vessel walls and proceed to attack the germs. If the blood corpuscles are finally victorious, all the microbes are killed off, while the leucocytes, having finished their work wander back into the lymph-stream and are carried thence to other parts of the body. Larger cells arrive to remove the débris, which includes the bodies of dead bacteria and dead leucocytes, blood-clot, fibrin and disintegrating tissues. The giant cells are in turn eaten up by the fibroblasts, and the process of repair from henceforward is similar to that in healing by first intention, Nature making use of the dead material as food for the new structures.

If the bacteria win the battle for the time being, the leucocytes continue to accumulate in still larger numbers, and the bacteria continue to grow. As the struggle proceeds, more and more of the body cells are sacrificed, and the inflammatory area enlarges. The swelling, redness, heat and pain become severe. Finally all this dead material may be liquefied, forming a thick yellow fluid known as pus, or, more popularly, "matter." In order to prevent extension to more distant

parts of the body, the cells of the body form a dense wall or capsule all round the abscess, so that the pus may not escape into the surrounding tissues or blood-stream. Such an abscess may burst on the surface and give relief to the patient or it may be opened by the surgeon; pain is lessened, the temperature falls, and healing commences. The abscess may break down the dense wall of protection and burrow in different directions below the skin and adjacent tissues, accompanied by an increase of fever and further deterioration in the patient's health: such a spreading abscess demands free incisions to let out the pus. At last, when healing begins, the scars are large and disfiguring, and often tendons are contracted, and muscles, nerves and bones so badly damaged as to be irreplaceable by Nature. In pre-Listerian days this was a common occurrence. It resulted in much loss of function in restored limbs, whilst pain was a distressing accompaniment from the very beginning until long after healing was complete.

It was a frequent experience also in those days for some of the pus to escape into the veins and give rise to the disease known as Pyæmia with the formation of abscesses in other parts of the body in such organs as the lungs, liver, spleen, kidneys or heart, which could not be reached by the surgeon; or perhaps other diseases, such as erysipelas or tetanus would complicate the injury and add to the patient's sufferings. But what surgeons dreaded most of all was the appearance of a grey slough in the wound that signalled the

onset of Hospital Gangrene. Then the surgeon was in despair. He knew that he might apply caustics, cautery, dressings; all without avail. Even amputation was of little use, for the disease might recommence in the stump. He also knew that once the disease gained a foothold in his surgical ward there was sure to be a spread to other patients, whatever his efforts to the contrary. Meanwhile the patient became very ill indeed, and his whole system was poisoned; however strong and healthy his constitution, it usually proved too weak for this dangerous enemy, and recovery was exceptional.

When a surgeon of pre-Listerian days began the treatment of a wound, he concerned himself first of all, as do surgeons nowadays, with the arrest of bleeding. Fashions changed in this, as in other things, and many methods had been employed. Such were the application of cold, or of various hot or boiling substances, pressure, twisting the ends of the vessels, or applying the red-hot cautery to the surface of the wound, which caused coagulation by burning. As the course of the circulation became better understood, ligatures were introduced for tying the arteries, and in spite of periodic fluctuations in favour of the other methods this remained the favourite plan. In Lister's time silk or linen threads, manufactured in the ordinary fashion, and prepared by drawing them through beeswax, were the common form of ligatures. After setting the bones and approximating the other parts, drainage had to be provided for the pus.

This was very important. To secure drainage the long ends of the ligatures were left hanging out of the wound, and the stitches, or sutures of wire, which held the skin together were placed far apart. The surgeon's theory was that the pus found its way through the wound along the paths made by the ligatures, and that the openings between the stitches allowed for its escape. This did not always happen, for in wounds caused by injuries or in operations small vessels were not considered sufficiently important to seal up, as is done to-day. There was, therefore, a large amount of blood-clot in every wound, which had two deleterious consequences : one was that it formed a solid mass and prevented the escape of pus, the other was that it offered a most favourable home for the growth of pathogenic bacteria. Often so much bleeding occurred that it was necessary for the surgeon to open up the wound each day and wash out the collection of blood-clot and pus. The ligatures, being septic and unabsorbable, acted as foreign bodies, set up irritation and pus formation, and finally were sloughed away, frequently resulting in a recurrence of bleeding where the vessel had not healed properly. If healing took place in such a case, it began at the bottom of the wound by granulations, and could not be completed until the mass of putrefying matter and ligatures had been extruded. Just about this time, 1859, Chassaignac, a Frenchman, introduced rubber tubes for the drainage of pus, which, though not used much at the time, are now in favour

for wounds that are septic when they first come under the surgeon's care.

The next thing to consider was the type of dressing to be applied to the wound. In nothing else in the long practice of surgery have there been such changes as in the methods of dressing a wound. All kinds of substances have been used, varying according to the notions in vogue at different times. In spite of the fact that many wise men had observed that Nature did not manage so badly if left alone, there were few surgeons who dared to be so original: for what patient would employ a doctor who put nothing on his wound! Mankind has always paid the penalty for the attitude of mind that prompts the ignorant to demand from the physician "a bottle of something." Several ways of treating a wound were in fashion in the middle of the nineteenth century. One, the cleanest of all, was by means of the water bath or irrigation of the wound. This had many advantages over the other methods, and many successes were claimed for it, but it was slow, cumbersome and costly. Baths of various shapes and sizes and other apparatus had to be provided. In some cases the treatment was continuous, and then the whole limb, and often the patient himself, was immersed in a bath of water the whole of the time. Here the patient lived, ate and slept. In other cases the affected part was only immersed for a certain time each day. Another way of carrying out this treatment was by means of an apparatus so placed that a constant stream of water trickled over the

wound by day and night. The water might be hot, tepid or cold, or it might contain certain medicinary substances, according to the theories and experience of the surgeon. This treatment was soothing, it helped to prevent sepsis, or, if sepsis was already present, it washed away the discharges; but the presence of so much fluid tended to make the tissues boggy, and healing took a long time. The water bath was greatly favoured in Germany, though it was not used much in this country.

Those who held very strong views as to the devastating qualities of the atmosphere took the most careful measures to shut out these supposedly noxious gases, only to find, alas! that when gangrene had its way gases more noxious still were formed in the wound itself. Having approximated the parts as tightly as possible, they sealed the wound by means of collodion, goldbeater's skin, caoutchouch, block tin, adhesive plaster and other substances. These were applied at once, and very closely, so that not a bubble of air could penetrate into the wound. Then compresses and bandages completed the dressing. If by chance the wound were aseptic at the time of application, and the surgeon and his hands and instrument more than usually clean, the results were good, the tight-fitting cover preventing infection from without. So may be explained the good results that followed in certain cases. But in others the effects were disastrous, for when pus formed there was no escape. This method of treatment was known as the Occlusion Method.

There were some enterprising surgeons, in Germany chiefly, who followed a course directly opposite to this method of occlusion. Apparently they did not believe in the harmfulness of the atmosphere or its constituent gases. Having observed the manner in which Nature worked, they were struck by the simplicity of the method of healing by scabbing; this they attempted to imitate. The sides of the wound were brought together, no dressing or coverings being applied. The injured part was put to rest on a cushion. Over the wound, but at some distance from it, a piece of linen was placed to act as a canopy to protect from dust and flies. A fine scab soon formed, which the surgeon expected to act as a satisfactory dressing. This method was often successful. If pus formed the scab was thin enough to allow the discharges to escape, whilst the absence of interference on the surgeon's part saved the wound from the introduction of sepsis. Other surgeons, not quite so confident, applied certain powders, or caustics or balsams to the wound to help in the formation of a scab.

Robert Liston, a surgeon at University College Hospital at the time when Lister was a student, strongly disapproved of the Occlusion Method, and invented what he called a Water Dressing. The wound was washed with a stream of cold water to remove foreign bodies, the ligatures were left hanging out, the edges of the wound were drawn together at intervals with sutures of waxed silk, or gold, silver or iron wire, or with plaster or bandages. Thus plenty of openings

were left for drainage. Over the wound was placed a piece of material soaked in water—to keep the region cool! This was changed frequently, though the originator mentions every two or three days. Instead of keeping the wound cool, the moist dressing quickly became as hot as the inflamed part and acted as a fomentation.

Professor Syme, also dissatisfied with the Occlusion Method, invented a method of his own, known as the Dry Dressing. He left the wound open for a few hours at first, though later on he found it better to close it up at once. But he provided for free drainage by placing the sutures at some distance from each other and leaving the lips of the wound fairly wide apart. Pads of folded lint were applied along each side of the opening, but not over the opening itself. Then over the top of the wound, covering the opening, and extending on to the pads, was a piece of lint to absorb the discharges. A bandage was then applied so that gentle pressure to the bottom of the wound was exerted through the pads at each side. This pressure forced the pus outwards into the covering lint. The dressing was first changed on the fourth day, and after that every two days. This was a great improvement on the Occlusion Method, and it was the procedure adopted and followed by Lister until he brought out his first antiseptic dressing.

CHAPTER V

We now return to Lister, who, as Professor of Surgery in charge of wards in the Glasgow Royal Infirmary, had many problems to solve, the principal being that of sepsis. The surgical wards for operation cases were in the new buildings, opened in 1861, and were constructed upon an up-to-date design. Lister, who believed in strict cleanliness, was very particular in the management of his cases, and he refused to allow more than the number of beds originally allotted to his wards when the plans for the building were drawn up. In spite of all his care, however, things were very little better here than elsewhere, for he had the usual outbreaks of pyæmia, erysipelas, and hospital gangrene. Constantly faced with the problem of suppuration, he directed most of his energies to the study of this question. His researches on Inflammation had given him certain clues, and now he was hard at work experimenting upon suppuration in general and suppuration in blood clot in particular. His inclinations lay in the direction of "conservative" surgery, that is, he was anxious to preserve the use of a limb and prevent an amputation, but such a course

was more often than not impossible, owing to the dangers of suppuration. Mr. Syme, with whom he often discussed the question, was of the opinion that conservative surgery was a mistake, and that probably the best plan in a severe case of compound fracture was to amputate the limb at once.

A clue to the cause of sepsis had been discovered by a young Hungarian doctor named Semmelweis, but owing to the fact that he did not publish his results for many years, and that when he did they were ridiculed by his countrymen, and so did not reach the outer world, Lister knew nothing of this work till more than twenty years after he had commenced his own antiseptic treatment. In 1846 Semmelweis was assistant physician in the large maternity hospital of Vienna, which admitted about 7,000 women annually. He was a keen pathologist and spent a great deal of his time in the post-mortem room, examining the dead bodies, to find out the cause of puerperal fever, a disease which was responsible for the death of a large percentage of the newly-delivered mothers in the hospital. Many explanations were forthcoming from other authorities, but none that satisfied Semmelweis, who worked assiduously to find the origin of this dreaded infection. When one of his colleagues died from blood-poisoning following upon a wound received whilst making a post-mortem examination, he recognised that this disease had many resemblances to puerperal fever. He realised that it was due to the same

cause—infection from without. At first he thought the source of infection could only be from the dead body, for he had not failed to notice that the percentage of deaths was much higher in that part of the hospital which was attended by the men students, who often passed straight from the post-mortem room to take their place by the side of some mother needing their help in the birth of her child. In the other part of the hospital, employed for the training of midwives, who never entered the post-mortem room, the mortality was much lower. Later on Semmelweis taught that puerperal fever was caused by any decomposing animal matter, either from the dead body or from a living person suffering from disease. This infection he believed could be conveyed by the hands of the attendant, and he insisted on the students washing their hands in chlorine water before and during attendance on the women in labour. By these means the mortality in the students' division was reduced below that in the midwives' division. Unfortunately, Semmelweis did not publish his ideas until 1861. In the meantime, he had been ridiculed, persecuted and deprived of his appointment, and had retired to his native city of Buda-Pesth. The publication of his book led to further persecutions, his mind became deranged, and he was placed under restraint for a time. In 1865, the very year when Lister made his great discovery, Semmelweis died from blood-poisoning contracted during his researches. It was not until towards the end of the century,

and after Lister's teaching had been accepted almost universally, that the genius of Semmelweis the martyr was recognised by his fellow-countrymen and his name rescued from oblivion.

Lister's scientific researches and his practical work since his graduation had convinced him of certain truths about inflammation and suppuration which he had been teaching publicly for some years before 1865. In the first place, he did not believe, as others did, that it was the oxygen or the other gases in the air that caused wounds to suppurate. Along with others, he had noticed that in cases where a broken rib punctured the lung, thereby causing only an internal wound, the air rushed in large quantities through the opening from the lung into the pleura (the membranes covering the lung). Internal bleeding and injured tissues were there, but no pus formed. Why? He could not explain, nor could others. If with that broken rib there was also an external wound and the air rushed in from the outside, suppuration followed. Yet it appeared to be the same atmosphere. Again, many surgeons, convinced that contagion lay in the atmosphere, adopted the method known as "subcutaneous surgery." This consisted in making an incision of the skin only large enough to admit the knife up to the handle. All the surgery was performed under the skin, the handle of the knife occluding the opening and preventing the entrance of air. This method had only a limited application. In spite of these precautions, however, such wounds often

became septic, and their after history was worse than in the open wounds because of the pent-up pus. In the end they often had to be opened up very widely indeed. If no air was admitted, how did these wounds become septic?

Secondly, he suspected that in some unexplained manner suppuration *was* due to contact with the atmosphere. If not, why did closed wounds remain pure?

Thirdly, he had noticed that it was not overcrowding alone that encouraged the spread of hospital diseases. Only when his wards contained a large proportion of patients with discharging wounds were these evils present in their worst form. When such cases were very few in number or absent altogether, the wards could be kept free from infectious diseases. He came to the conclusion, therefore, that in some way it was the emanations from foul discharges that were the cause of the mischief. For this reason, he welcomed the arrival of simple fractures in his wards, even though they were devoid of so much professional interest.

Fourthly, he believed that putrefaction—or decomposition—of the natural discharges following an incision was the essence of suppuration and wound infection, and that wound infection could not occur if suppuration were not present.

This was as far as Lister had travelled, and this was what he taught his students.

The fermentation of wine and beer and the healing of compound fractures would seem to

have no connection with each other. Yet it was through an investigation into the former that the riddle of the latter was solved. Early in 1865 Lister was discussing his problems with Dr. Thomas Anderson, the Professor of Chemistry in Glasgow, who advised him to read the writings of Pasteur. Lister did so and therein found what he sought: it was not the air, but *germs*, that were the source of infection. Pasteur showed that putrefaction was a form of fermentation caused by the introduction into organic matter of tiny forms of life existing in the atmosphere and invisible to the naked eye. Lister realised that if this theory were correct it explained much that had puzzled him.

Although the process of fermentation had been known to mankind from the earliest days, its cause was not understood: it was not until the nineteenth century that scientists approached this question along the right path. In 1810, a French confectioner and fruit preserver, M. Appert, published a book on "The Art of Preserving all kinds of Animal and Vegetable Substances for Several Years." He placed his fruits in tightly corked bottles and subjected them for a time to the temperature of boiling water. He was nearly always successful in preserving his fruits by methods very different from those of pickling or desiccating to which he had been brought up. These results attracted the attention of Gay-Lussac, the famous French chemist. He was very surprised to find that grape juice, preserved in this manner

for a year, fermented in a few hours after it had been poured into another vessel. He came to the conclusion that it was the oxygen of the air that initiated the fermentation. The vegetable nature of yeast was discovered by a French chemist, Cagniard-Latour, in 1837. He pointed out that yeast consisted of small bodies which could reproduce themselves, that these small bodies were living cells, that they belonged to the vegetable kingdom, and that they could only act upon sugar as long as they retained their vitality. He concluded that it was their growth and their action upon the sugary solution which set free the carbonic acid and formed alcohol. At the same time a physiologist named Schwann of Berlin was also working on yeast, quite independently of Cagniard-Latour. He proved that the vegetable cells did indeed split up the sugary solution into alcohol and carbonic acid and that therefore they were the cause of fermentation. Then the great Baron von Leibig, who had a world-wide reputation as a chemist, set out to discredit these views in a paper he published on " The Phenomena of Fermentation and of Putrefaction." He argued that fermentation and putrefaction were an example of the slow combustion that naturally proceeded in organic substances at normal or slightly raised temperatures. Leibig's theories were accepted by the scientific world, and thus the belief in the existence of germs and the birth of the science of bacteriology were delayed for a time. If students of chemistry in Lister's young days

were taught anything about fermentation it was Leibig's theories in which they were instructed.

Louis Pasteur (1822–1895), the son of a French tanner, was a Professor of Chemistry in the Faculté des Sciences at Lille, when, in 1856, a manufacturer of beet-root alcohol appealed to him for help in his problems. Pasteur had already established a reputation for his work on polarisation and crystallography. Through his observations he had been able to point out the difference in the two kinds of tartaric acids which have the same chemical composition, but different optical properties and crystalline form. He now began to work upon fermentation in order to help the manufacturer. He used the microscope and worked not only as a chemist, but also as a biologist, on the fermentation which occurs in tartaric acid, and from this he was led to the study of other forms of fermentation. He noticed that the little bodies found in alcoholic liquids were round when fermentation was healthy, that they became oval as the process proceeded, and that when lactic acid was forming they became very long. He proved that Cagniard-Latour and Schwann were right and, at the same time, he attacked the theories of Leibig. Whilst working on the lactic acid fermentation which occurs in the souring of milk, he noticed microscopic forms of life in the fluid: these were the microbes that we now know as the lactic acid bacteria. He introduced these rod-shaped lactic acid germs into another liquid and observed that they began to multiply in their new sur-

roundings and to produce the same form of fermentation as that which occurred in the soured milk. As he watched the growth and activities of these newly discovered microbes, the idea occurred to him that he might be able to produce different types of fermentations by inoculating a liquid with different types of germs. A series of careful experiments proved the truth of this hypothesis. He thought that these observations might throw some light on the disputed question of spontaneous generation which had for so many centuries exercised the minds of scientists, philosophers, poets and men of religion. His friends, who looked upon this research much in the same way as we regard the old search for the Elixir of life, tried to dissuade him, but Pasteur was not deterred. He commenced with the study of the atmosphere. He found that by drawing air through a plug of cotton-wool in a glass tube there was deposited in the interstices of the wool a large amount of dust. When a portion of this wool was placed in a pure, sterile liquid which had previously been boiled, a turbidity slowly appeared and fermentative changes began to take place. He was convinced that the air was not to blame but that the micro-organisms carried by the dust were the cause of the changes. But the wool itself might have caused the alteration? He disproved this by a series of simple and convincing experiments. He prepared a number of glass flasks with straight, drawn-out necks and filled them with a decoction of yeast, a highly putrescible substance.

These flasks were then boiled for a certain length of time, and before being removed from the flame the necks were sealed. As the flasks cooled a partial vacuum was thus formed above the fluid. After an interval of time the flasks were opened in different localities: some in Paris where the atmosphere was laden with dust, others in cellars where the air was undisturbed and the dust had settled, and the remainder on the Mer de Glace of Mont Blanc where the air was exceedingly pure. With careful precautions against contamination the necks were broken and air allowed to rush in and fill the vacuum, after which they were resealed immediately. In those flasks which had been exposed to the purest mountain air only one flask in twenty showed signs of developing life. Only one in ten of the flasks opened in the cellars began to ferment. But every one of the flasks which had been exposed to the dust of a large town fermented vigorously. Pasteur then prepared another series of flasks which he filled with a decoction of yeast. These also were boiled, but instead of sealing them, he drew out each neck into a long, thin tube, which he bent at various angles. Although left unsealed for long periods in positions where there was plenty of dust and movement of the atmosphere, the contents of these flasks remained sterile. The dust had been arrested by the angles and adhered to the glass as the air passed in after cooling and during the constant movement of the air in and out of the flasks occasioned by the daily variation of temperature. If, how-

ever, one of these flasks was tilted sufficiently to allow the fluid to reach an angle which contained dust, soon the usual cloudiness appeared and living microbes came to grow in the liquid, initiating fermentation. These experiments proved conclusively that it was not the gases of the atmosphere or any chemical or physical property of it that caused fermentation, but the presence in it of living microscopic creatures. Pasteur then repeated these experiments with sterile animal fluids such as blood and urine. He found that if blood and urine from healthy persons were received with suitable precautions into properly sterilised vessels, these fluids were devoid of germs and could be kept free from putrefaction for a long time if dust were not allowed to enter the vessels. A further discovery of Pasteur's was the existence of another class of microbes which he named anærobes because they possess the faculty of being able to live without free oxygen. These tiny creatures take their oxygen in a combined form from the material in which they live, and in doing so decompose it.

From these experiments Pasteur arrived at the following conclusions :—

That life arises only from living cells, and cannot be "spontaneously generated." That fermentation is caused by minute forms of life which are carried about by the dust of the atmosphere. That putrefaction is a form of fermentation and is caused by the growth of microbes in animal and vegetable substances. That vegetable and animal substances have no

natural tendency to putrefy and that they can be kept free from contamination by microbes even in the presence of oxygen.

In a speech on "Spontaneous Generation" delivered at the Sorbonne on April 7, 1864, Pasteur related his experiments before a distinguished assembly, and concluded with these arresting and eloquent words:—

"This must be noted that everything in air save its dust can easily enter the flask and come into contact with the liquid. Imagine what you choose in the air—electricity, magnetism, ozone, unknown forces even, all can reach the infusion. Only one thing cannot enter easily, and that is dust, suspended in air. . . . And, therefore, gentlemen, I could point to that liquid and say to you, I have taken my drop of water from the immensity of creation, and I have taken it full of the elements appropriate to the development of inferior beings. And I wait, I watch, I question it, begging it to recommence for me the beautiful spectacle of the first creation. But it is dumb, dumb since these experiments were begun several years ago; it is dumb because I have kept from it the only thing man cannot produce, from the germs which float in the air, from Life, for Life is a germ, and a germ is Life. Never will the doctrine of spontaneous generation recover from the mortal blow of this simple experiment."

Lister was charmed by the "simplicity and conclusiveness" of these experiments. Later

on he repeated them himself, and successive generations of students in Glasgow, Edinburgh and London were instructed by the demonstration of flasks of clear urine that had been preserved sterile for many years, although exposed to the air through the tortuous open necks. Lister was convinced of the truth of Pasteur's opinions. Independently he had got as far as the belief that putrefaction—or decomposition—of the natural fluids in a wound was the cause of sepsis and infection. But what caused the putrefaction? Here was the answer. The body was to be likened to the flask containing natural organic substances, the skin being the covering which preserved the contents from the influence of the atmospheric dust. If the glass flask containing urine were broken or unsealed and the germ-laden dust allowed to enter, decomposition immediately set in. Similarly, if the skin were broken or cut by accident or by the surgeon, germs were conveyed to the interior of the body, and putrefaction and sepsis were the result of the fermentation-like changes started in the blood and tissues. Herein lay the difference between simple and compound, lacerated fractures, between a healthy, intact body and one that had been opened by the surgeon. In a simple fracture the blood and flesh remained sterile and healed without sepsis because the skin, which takes the place of the glass, had not been broken. "Now!" thought Lister, "there must be some way to make an open wound behave like a closed

one. I must so treat an open wound that the body, though no longer closed, shall be like the flasks with the tortuous necks, refusing to admit the microbes because of an impassable barrier. How can I do it?" There could be no guarding of the human flask by tortuous passages, nor could the contents be boiled and sealed up! It was not possible to filter the atmosphere of its dust. There remained but one way—*to apply some chemical substance in such a manner that not only would the microbes already present be destroyed, but the germ-killing substance must act as a barrier between the wound and all sources of outside infection, so that the entrance of further microbes would be prevented.* This was the aim of what Lister called his Antiseptic System.

CHAPTER VI

THE Antiseptic System invented by Lister was a new principle. It was not the first time that antiseptics had been used and Lister was unfortunate in the choice of his nomenclature, for it gave the impression that he was only trying to do what many other surgeons before him had attempted. The struggle against putrefaction was as old as surgery itself; but the difference between the old practice and the new was revolutionary. The old method had been to apply some substance to a wound to combat evil already established there, no efforts being made to prevent further infection which occurred through septic hands, instruments, towels, dressings, and ligatures, and by other means. Lister did not even introduce a new antiseptic; he used an old one. His method, based upon the theory of infection by microbes, was to prevent these from entering and so to produce *an entirely new kind of surgical wound—an aseptic wound.* Where sepsis had already commenced, as in injuries inflicted by an accident, his plan was to clear out the existing evil by means of an antiseptic and then by the same means to prevent the entrance of other microbes.

The word antiseptic had been in use for more than a hundred years, and it denoted any substance that opposed or counteracted putrefaction. Many substances had been employed for this purpose, including salt water, myrrh, the oil and wine of the Good Samaritan, and various balsams, one of which was Friar's Balsam, well known to all. The antiseptic properties of alcohol had long been recognised, one of its uses being that of preserving anatomical museum specimens. Glycerine, chlorine and its compounds, iodine, and chloride of zinc had also been used. The mummies of ancient Egypt are a good example of the successful use of preservative substances which prevent decomposition by microbes.

Lister considered the qualifications of the different antiseptic substances known in the middle of the nineteenth century, and remembering that he had heard of the reliable disinfecting properties of carbolic acid upon the sewage of Carlisle, he spoke to his colleague, Dr. Thos. Anderson, who supplied him with a sample of carbolic. This was the crude acid, generally known as German creosote, not the refined substance which is now produced for surgical use. It was dark, tarry, chemically impure, and possessed an objectionable smell.

The antiseptic properties of coal tar, of which carbolic acid is a derivative, were first noted in 1815 in France. From 1840, creosote was used for protecting railway sleepers and ship's timbers. The virtues of powders consisting of coal-tar

preparations were proclaimed by many, as witness the following advertisement of the times: "the action of this disinfectant substance seems to arrest the work of decomposition; it keeps away the flies and prevents with certainty the production of worms." In 1834 carbolic acid was discovered by Runge and in 1851 was used in England for the preservation of dead bodies. An English chemist named Calvert became interested in carbolic acid, and it was he who later devised methods for producing purer forms of the chemical. In 1863, Jules Lemaire, a pharmaceutical chemist in Paris, published a book on the subject, written after he had concluded a long series of investigations into the nature and action of carbolic acid, a second edition appearing in 1865 in which he accepted the theory of microbic infection. He recommended the employment of carbolic acid for many diseases, and also used it for preserving food and anatomical specimens and as a hygienic disinfectant. Lister did not see this book until two years after he had commenced his Antiseptic System. Carbolic acid was used in France for a time, though it brought about little change in surgical treatment. It was applied to a septic wound as a dressing, but achieved no better results than many other substances, probably because in the dressing of the wounds sufficient care was not taken to prevent a fresh infection. The usual method of procedure, both in operations and in treating injuries or abscesses, gave such frequent opportunities for the entrance of

germs into the interior of a wound that any substance, however powerful, when applied merely to the surface, had no influence whatever upon the internal suppuration.

Lister applied his Antiseptic System first of all to the treatment of compound fractures. Compound fractures were frequent in Glasgow, and Lister found that they were the commonest cause of the origin of hospital diseases; the larger the number of compound fractures and open wounds in a ward, the more likely was there to be a serious spread of infection.

Except for a failure in March 1865, which Lister believed to be due to improper management, the first patient treated in the new way was a small boy of eleven years of age suffering from a compound fracture of the left leg caused by the wheel of a cart passing over the limb a little below the middle. There was very little blood in the tissues, but the wound was deep and, therefore, air must have entered. A piece of lint soaked in the undiluted carbolic acid was applied to the wound, after which the limb was padded and placed in the usual splints. The limb was left undisturbed for four days, about which time it was usual to find that suppuration and disturbance of the general health generally made their appearance in cases treated in the old way. But Lister found, to his joy, that there was no sign of suppuration in the wound, though the skin in the immediate vicinity was tinged with a slight blush; the patient's health and appetite were excellent. He then dressed

the wound with carbolic acid diluted with water, because the pure acid seemed to be too strong for the skin around the wound. This dressing was kept on for five days, during which time the redness disappeared. There was no pus from the interior of the wound, but one or two superficial sloughs, caused by the action of the acid on the surface of the wound, were separating. He decided, therefore, that the antiseptic was still too strong and substituted a piece of lint dipped in a mixture consisting of one part of pure acid in twenty parts of olive oil. This he left in position for four days. A fortnight had now elapsed since the boy's admission, and not only was the patient in good health and suppuration absent, but the wound seemed to be behaving exactly in the same way as a closed wound except for a tiny drop of pus on the surface, which seemed to be caused by the caustic, or chemical, action of the acid. It was plain that the tissues were healing in a healthy fashion.

Lister, elated with the promise of success, replaced the carbolic with a simple water dressing, and at the expiration of six weeks, finding the bones firmly united, he discarded the splints. This was surely a record for speedy cure in those days! He does not mention the cleansing of hands and implements with the antiseptic in this case, as he does later on, but it is most probable that he adopted such methods from the very first, for such an acute observer would not fail to realise that, if germs existed in the dust of the atmosphere, they were likely to be found also on

surgeon's instruments and on the materials of the dressings.

It was acknowledged by Lister that this had been a favourable case owing to the youth of the patient and the absence of much bleeding and great damage to the tissue, and was, therefore, not to be regarded too optimistically. He was much encouraged, however, by the absence of suppuration in the wound and by the fact that healing had taken place as quickly as in a closed, or simple, fracture. This was most unusual. At last he seemed to be in sight of his objective. But there was much to learn concerning the details of his system, and Lister, being of a modest and painstaking nature, learnt something fresh from every case and was always ready to confess his mistakes and to devise other methods when those he tried had been found unsatisfactory. Also, he showed an eagerness to accept and adopt suggestions from other men, a characteristic which does not always distinguish pioneers.

His second case was a labourer, aged thirty-two, who had a compound fracture of the leg with a large amount of bleeding. This was treated with lint dipped in the undiluted acid by Mr. Miller, the house surgeon, according to Lister's directions. In the evening the dressing was changed for a similar one covered with oiled paper to prevent the antiseptic drying up. The next day Lister saw the patient and advised that the dressing should be left undisturbed and that over the oiled paper another piece of lint soaked

with acid should be applied daily. This was done, the lower piece of lint under the oiled paper being left in contact with the wound for eleven days. When next examined, a scab, or crust, had formed consisting of the dried blood, acid and lint. This separated, revealing beneath a perfectly healing sore, free from suppuration. There had been little pain, no disturbance of health, no sepsis. Water dressing was now applied, and by the sixteenth day the wound was closed up except for one small spot which was granulating in a healthy fashion. Unfortunately, Lister had to leave Glasgow for a few weeks, and during his absence gangrene attacked the small sore, necessitating amputation of the limb. Had Lister been at work it is probable that this would not have happened. In spite of this bitter disappointment his confidence in this new treatment remained unshaken: two lesser injuries, handled with a similar technique to that already described, healed with unusual ease. These were not counted as test cases.

From these experiences Lister learned certain lessons. He observed that carbolic acid was a satisfactory antiseptic to use. It was painless upon application, having an anæsthetic action upon the nerve endings. As it mixed with the blood in the wound its caustic or destructive properties were much reduced, and there was formed a tenacious mass, which later became a hard crust, or scab, on the surface of the wound. This crust retained its antiseptic powers for some time, prevented the entrance of microbes, and

allowed repair to proceed beneath exactly as if the wound were a closed one. In short, after destroying the majority of microbes already in the wound, it helped to bring into action "Nature's Surgery," or healing by scabbing. It also had this great advantage, that, after the application of the splints, the wound could be left undisturbed except for the daily renewal of the upper dressing. The upper dressing was to prevent microbes gaining access to the crust and to renew the acid in the crust.

But carbolic acid had disadvantages. There was no doubt that it gave rise to a discharge from the surface of the wound which when mixed with carbolic acid was very irritating to the skin round about. This discharge consisted of serum (or the fluid portion of the blood). Lister thought that it would be advantageous to place over the whole dressing a hot fomentation to soothe the part and help to draw away the discharge. He sought to protect the crust formed of blood, acid, and lint with something more serviceable than oiled paper, oiled silk or gutta percha, the coverings then used for dressings. He therefore devised a protective made of thin sheet lead, but afterwards used block tin.

The next patient was an iron moulder, who had sustained a very serious compound fracture of the left leg, both bones being broken. There was much damage to the muscles and a large amount of bleeding. Here was a severe test for the Antiseptic System, for when Lister saw the patient three and a half hours had already elapsed from

the time of the injury. He squeezed out as much as he could of the clotted blood and applied lint and carbolic acid, which he covered with a piece of block tin larger than the lint. The leg was then set in pasteboard splints and a fomentation applied over the block tin protective. Each day the crust was damped with carbolic acid and the fomentations continued. From the fourth day Lister watched with anxiety for suppuration, but none appeared. The patient's health, sleep and appetite remained excellent, the swelling steadily decreased, and the wound behaved like a closed one, as in the previous cases. Gradually, as the wound healed, the overlapping tin and crust were cut away on the circumference as the outer edge of the crust became softened by the irritating discharge. This was of great benefit, and prevented irritation of the surrounding skin. At the end of six weeks the bones were united, and very soon the extensive wound was closed by the usual scar, no complications having occurred from the beginning to end of the illness.

During his observations upon this case Lister made a discovery which startled him by its unexpectedness and importance. He found that the deeper portions of the crust of blood and carbolic acid were actually being transformed into living tissue! "The blood, though greatly altered in physical characters, and doubtless chemically also, had not been rendered unsuitable as pabulum for the growing elements of new tissue in its vicinity." He, therefore, realised that it would be possible to introduce carbolic acid deeply into the tissues,

believing that it would all be absorbed with the extravasated blood.

The fourth test case was that of a little boy, aged ten years, earning his living in a turner's factory, whose right arm was badly fractured, all three bones being broken, and muscles and skin torn and hanging loose in strips. A piece of bone was also protruding which had to be sawn away. This was a serious case indeed, and would probably have been treated by immediate amputation in pre-antiseptic days. Lister applied carbolic acid freely to the interior of the wound, including the exposed surface of the bone. The wound was too extensive to allow of approximation of the edges, consequently it was dressed with a surface covering of acid-soaked lint and the protective of block-tin, over which the fomentations were applied. The splints were so arranged that they were not interfered with as the dressings were changed. Everything went well except that about the fourth day a small quantity of pale grey discharge escaped from beneath the crust at one part. Lister, thinking this was due to insufficient use of the antiseptic, applied more, and still more. The discharge, however, increased in proportion with the increased application of the carbolic, and after examination under the microscope Lister came to the conclusion that this was pus due to chemical action only from stimulation by the acid through a crust thinner than in previous cases. When the crust was detached he made another surprising discovery, equal in importance

to the one made in the last case. He found that this deep and extensive, ragged wound had been gradually filled up with newly growing elements, and that not only had the compound of blood and carbolic acid acted as a scaffold for new living tissue, but the tissues which had been killed by violence and those destroyed by acid had similarly been organised, and the whole mass formed a new, living structure. And no septic suppuration had occurred. This was matter for congratulation. Hitherto the presence of dead tissue had always meant suppuration. He therefore concluded that dead tissue itself was not dangerous: it was only when sepsis supervened that it was to be feared.

The fifth test case was Charlie, aged seven, a fine, intelligent boy and a great favourite with Lister. The boy had been knocked down and run over by an omnibus crowded with passengers. There was a compound fracture of the right leg with a "frightfully extensive" wound, both bones being broken. He nearly died from shock and bleeding on account of which it would have been dangerous to amputate the leg, although there seemed to be no alternative: it would have been hopeless to try to save such a badly damaged limb by former methods of treatment. Lister decided to give the Antiseptic System a trial, and carbolic acid was applied very thoroughly into all the interstices of the wound and between the fragments of the bone. There was a wide gaping surface which could not be closed in owing to destruction of skin. This was covered with

carbolic acid-soaked lint and block tin, after which the treatment proceeded as in the last case. Charlie got on very well, and the very extensive open wound gradually healed as if it were a closed one; but this happy chain of events was suddenly interrupted by an unforeseen setback. Gangrene appeared in a small sore on the outer side of the leg which had not been treated with carbolic acid. Fortunately, after vigorous antiseptic treatment the gangrene was arrested and amputation avoided. This experience taught Lister the importance of applying the antiseptic with thoroughness even to the smallest sore.

Before this fracture was healed Lister made a third important discovery. A large piece of the broken bone died as the result of the violence and the subsequent deprivation of nourishment from the torn blood-vessels. When Lister saw this he was horrified, fully expecting to see the formation of quantities of pus and the expulsion of the diseased bone from the wound. It had always been taught that diseased tissues and bone *must* be expelled as foreign bodies. But he found that new granulations were growing up all round the diseased bone and sprouting from the bone itself. After a time all the dead bone was absorbed and new living bone appeared in its place to join up with the uninjured portion, thus preventing shortening of the injured limb. He concluded that in an aseptic wound the granulations could absorb old and dead tissue.

The remainder of the eleven test cases, an

account of which comprised Lister's first publication on the use of the Antiseptic System, were equally serious and instructive. All did well with the exception of one man who died suddenly towards the end of his cure from hæmorrhage, which was caused apparently by a piece of bone penetrating a large artery. One alcoholic patient, who had been drunk at the time of his very serious injury and continued restless for some time, subsequently developing delirium tremens, was obstreperous enough to test to its utmost any system of treatment. Yet his wounds slowly healed without suppuration. Lister discovered that it was perfectly safe to plug large bleeding wounds with carbolic acid-soaked lint without the appearance of the suppuration which had always ensued after plugging with ordinary lint. Also, if the caustic action of the acid occasionally produced any pus in the interior of the wound when introduced deeply, this pus was comparatively harmless; it gave rise to no fever, blood-poisoning, or other constitutional disturbances. Lister's house surgeon, Mr. Cameron, afterwards Sir Hector Cameron, found that a mixture of oil and carbolic acid answered as well as the pure acid; but since Lister had observed that the pure acid had no evil results in the deep tissues he was too cautious to risk the lives of his patients by dilution of the antiseptic. He now commenced to use melted crystallised acid, a much purer product, which was supplied to him by Mr. Calvert, the chemist.

Next the Antiseptic System was applied to the

treatment of abscesses. In those days abscesses of any size presented a difficult problem to the surgeon. There were only two methods of treatment: one was to open the abscess and allow the pus to escape; the other was to let it alone. If the abscess was opened, germs were likely to get in and the protecting barrier of fibrous tissue, which had hitherto managed to keep the pus localised, was now broken down by the action of fresh microbes. If the abscess were left alone, Nature sometimes affected a cure by destroying the germs already present and absorbing the pus, a result more likely to follow if the abscess were small. Sometimes, if unopened, the pus broke through the protecting barrier, the abscess enlarged, a new barrier was erected which localised the infection for a time, but the mischief was likely to spread until the abscess occasionally attained huge dimensions. The surgeon was then afraid to open it up for fear of serious consequences.

Lister's method was to take a piece of rag soaked in a mixture consisting of one part of pure carbolic acid to four parts of boiled linseed oil, and place it over the abscess before the operation. A scalpel was then dipped in the same mixture and the abscess opened underneath the rag which prevented any germs entering the wound. Lister knew that there could be no question of a protective crust here, for there must be an opening large enough to permit of the continued free escape of the pus. After experimenting with many substances and experiencing disappoint-

ments, he produced a paste, or putty, made from carbolic acid, linseed oil, and carbonate of lime. The putty was spread to the thickness of a quarter of an inch on a piece of block tin. This dressing was then applied with the tin uppermost, the acid-soaked rag or lint next to the skin not being removed until the very instant the putty was applied. The dressing was kept in place by adhesive plaster. Lister found this treatment satisfactory, and had great success with it. The tin prevented the evaporation of the acid. The putty prevented the entry of microbes, it continuously gave up its antiseptic to the wound beneath, thus acting as a reservoir of acid, nor could it be washed away by the discharges. The oil in the putty held the antiseptic more firmly than water; it gave up sufficient antiseptic to the discharge to keep it sterile but not enough to make it irritating to the skin. When the putty was removed in order to dress the wound, a piece of lint soaked in antiseptic was placed over the incision at once, and all manipulations were conducted underneath this antiseptic protection. This lint was not removed until the new dressing of putty was applied. Thus Lister was able to prevent the entrance of germs from the first incision of the abscess until the end of the cure. Large abscesses no longer continued to be the despair of the surgeon. Lister had a little patient, five years old, suffering from disease of the spine, with an enormous abscess reaching from the umbilicus to the middle of the thigh. Lister opened it in the Antiseptic way, let out a pound

of pus, and in four days the cure had progressed so well that there appeared only three-quarters of a drachm of clear, odourless fluid during the space of twenty-eight hours. He observed also that where such abscesses were connected with caries, *i.e.* disease of bone, as in spinal disease, there was a tendency to spontaneous cure under the Antispetic System once the irritating pus was withdrawn. This did not surprise him; already he had seen new bone replacing that which had died in compound fractures treated antiseptically.

The Antiseptic System worked to perfection in simple wounds where sepsis had not already commenced, and in incised wounds inflicted by the surgeon during operations. When an operation was in progress, Lister used a solution of one part of carbolic acid in twenty parts of water for cleansing the skin and washing out the wound. After the stitches were inserted the putty was applied as in the case of fractures and abscesses, the wound usually healing without sepsis and its complications in a remarkably short time. Another pleasant surprise awaited Lister. He soon discovered that it was not necessary to leave long ligatures hanging out of an antiseptically treated wound. He cut the ends short and left the ligature permanently in the wound instead of pulling it away as was customary.

Although it was common for pieces of glass or metal such as bullets or shrapnel to remain buried in the tissues for years without causing suppura-

tion, ligatures were always found to be dangerous. This was because the material of which they were composed was soft and porous, concealing in its interstices the germs of putrefaction; these developed in the blood and serum with which the ligature was surrounded. When the silk or linen had been steeped in carbolic acid for a time the germs were destroyed, consequently no pus was formed, and secondary hæmorrhage, usually the result of decomposition and softening of the artery and the blood-clot, did not occur. This opened up a new vista. Lister prophesied that it would be possible to tie arteries in their continuity in cases of aneurism, and that it would be no longer dangerous to ligature an artery close to the emergence of a large branch. Before applying these ideas to the human subject, he experimented upon an old horse on December 12, 1867. Under antiseptic conditions he tied the carotid artery in the neck close to a large branch with purse-silk that had been steeped for some time in carbolic acid. The horse made an excellent recovery. Indeed, its condition improved greatly under the good feeding and management of the veterinary establishment, but in five and a half weeks it died from old age. Lister, who made a post-mortem examination, found his expectations fulfilled. Not only had the artery been successfully occluded, but the ligature had been surrounded by strong fibrous tissue, and there were no signs of pus, granulations or softening of the tissues.

CHAPTER VII

Had Lister been given a choice of all the hospitals in the United Kingdom, he could not have selected a more favourable place for a thorough testing of his Antiseptic System than the Glasgow Royal Infirmary, notorious for the unhealthiness of its wards. Of his Antiseptic System Lister wrote in 1870, "Its effects upon the wards lately under my care in the Glasgow Royal Infirmary were in the highest degree beneficial, converting them from some of the most unhealthy in the kingdom into models of healthiness." The Infirmary consisted of an old building and the "New Surgical Hospital," erected in 1861. The four senior surgeons attached to the Infirmary had each charge of one female and one male accident ward in the new building, one ward for chronic male cases in the old building, and, in addition, several small rooms for special cases. The new building was the best of its kind. It consisted of four storeys and a basement, and upon each storey there were two large wards communicating with a central staircase, together with some smaller apartments. The wards were spacious and lofty, furnished with fireplaces and ventilation on the

most up-to-date principles, and with numerous windows along both sides. In the intervals between the windows were placed the beds, sufficiently far apart for each patient to be surrounded by the requisite amount of fresh air. In fact, the building seemed to be ideal in every way, except that the water-closets opened directly into the wards, instead of into the passages. But this handsome building, concerning which so many hopes had been entertained, was a great disappointment. Very soon erysipelas, pyæmia and hospital gangrene appeared, and from statistics collected for the Managers of the Hospital it appeared that the wards on the ground floor, whoever might be the surgeon in charge, suffered most; whilst those on the floor above were somewhat better. Lister's male accident ward was on the ground floor, and his female ward on the floor above. Conflict often occurred between Lister and the managers on account of the former's refusal to allow more beds than had been arranged for in the original scheme. "It is," said Lister, "fairly attributable to the firmness of my resistance in this matter that, though my patients suffered from the evils alluded to in a way that was sickening and often heart-rending, so as to make me sometimes feel it a questionable privilege to be connected with the institution, yet none of my wards ever assumed the frightful condition which showed itself in other parts of the building, making it necessary to shut them up for a time."

In 1867, only six years after the new building

was opened, the mortality was so great in the other male accident ward on the ground floor, which was separated from Lister's by a passage only 12 ft. wide, that the managers closed the ward and ordered an investigation into the state of the drains and foundations. They were greeted by a horrible surprise. "A few inches below the surface of the ground, on a level with the floors of the two lowest male accident wards, with only the basement area, 4 ft. wide, intervening, was found the uppermost tier of a multitude of coffins, which had been placed there at the time of the cholera epidemic of 1849, the corpses having undergone so little change in the interval that the clothes they had on at the time of their hurried burial were plainly distinguishable." In addition to this, the hospital was in a most unhealthy situation. Adjacent to one end of the building was the large old Cathedral churchyard, a place often used for the "pit burial" of paupers in addition to ordinary interments. One of these pits was close to the patients' recreation ground, and a few yards only from the windows of the surgical wards.

Lister visited the pit for the purpose of reporting. "The pit, which was standing open for the reception of the next corpse, emitted a horrid stench on removal of some loose boards from its mouth. Its walls were formed, on three sides, of coffins piled one upon another in four tiers, with the lateral interstices between them filled with human bones, the coffins reaching up to within a few inches of the surface of the ground."

There were several such pits. One of the Glasgow newspapers reported that "the Dean of Guild is said to have computed that 5,000 bodies were lying in pits, holding eighty each, in a state of decomposition, round the Infirmary." Just beyond the churchyard was another huge burial-ground. Not only were these horrors in close proximity to the Infirmary, but at right angles to it was the Fever Hospital, only separated from it by a distance of 8 ft. "About half the wards of the Fever Hospital are used for surgical cases," says Lister in a footnote to the article in which these conditions are described.

The entire Infirmary, consisting of old and new buildings, and containing as many as 584 beds, stood upon the small area of two acres of land. As the institution was always full to overflowing, the general unhealthiness of the place and its surroundings can easily be imagined.

At the time when the other ground-floor ward was closed and the inquiry instituted, the Antiseptic System had been practised in Lister's ward for nine months. In spite of the awful conditions, these wards had been free during the whole of that time from hospital diseases in any form. Not a single case of pyæmia, erysipelas or hospital gangrene! Lister regarded the experience as conclusive.

The Managers set to work at once to improve things, as far as could possibly be done in the circumstances, and there is no doubt that the measures taken did something to purify the atmosphere of the place. Hospital diseases,

however, though reduced to some extent, still continued in every surgical ward except those under the care of Lister. For the remaining two years and three months of his residence in Glasgow the same general healthiness persisted in his wards, making altogether a total of three years during which there was immunity from the evils of hospitalism. Since commencing the Antiseptic System Lister had treated thirty-two cases of compound fracture, some of them so badly mangled that their lives were despaired of, yet not a single case had developed pyæmia. In addition to this, he found it was possible to carry out his ideas of conservative surgery, thereby saving many limbs that would otherwise have been lost. During the same period he had had forty cases of amputation, with a mortality of only six. This was a tremendous improvement on the statistics for the two years preceding the antiseptic era, when the mortality was as high as sixteen in thirty-five. The six deaths occurred in cases where the severity of the injury was so great or the constitution of the patient so weakly as to offer slender hopes of life. He had, unfortunately, two cases of pyæmia after amputations; one he attributed to mismanagement and the other developed pyæmia before admittance to the hospital. But in each case the disease was confined to the original sufferer, and did not spread through the wards. The first patient was treated during Lister's absence by a colleague, who perhaps did not thoroughly understand the Antiseptic System.

As to erysipelas, several patients were admitted already suffering from the disease, but only one developed it in the wards. Nowadays a case of erysipelas would never be admitted to a surgical ward, and, judging by our present knowledge, it is quite likely that the one who developed the disease in the wards was infected by the others. In spite of the admittance of these cases erysipelas was kept in check. Hospital Gangrene, which formerly was "both frequent and severe" and "committed fearful ravages," was practically banished. During the first nine months there was not a single case, while the remaining portion of the three years saw but one or two small, isolated sores which rapidly yielded to the antiseptic treatment. With hospital diseases rampant in other parts of the Infirmary, it would be impossible to keep infection completely away from Lister's wards, considering that nurses, surgeons and others were passing from ward to ward, and that it had not yet been realised that strict isolation was a necessity. The occurrence of these small spots of gangrene made it clearer than ever to Lister that it was of the utmost importance to treat even the tiniest abrasions antiseptically.

Owing to the continuance of this unusual healthiness, Lister became less vigilant about overcrowding in his hospital wards. He had formerly insisted on fires all through the summer for the sake of the increased ventilation; now they were unnecessary. He permitted cribs for children in the wards and,

in times of pressure, allowed two children to sleep in one bed, thus decreasing the cubic space of air per patient. During these three antiseptic years the wards did not receive their annual spring cleaning, the Superintendent giving as his reason, " that as those wards had continued healthy and as there was nothing dirty in their appearance it had seemed unnecessary to disturb them." The ideal was now in sight. A hospital ward had attained to " a degree of salubrity equal to that of the best private houses "! There was, therefore, no need to pull down existing hospitals in order to erect in their places the tin huts suggested by Sir James Young Simpson, and Lister prophesied that soon all surgical hospitals would enjoy the same healthy atmosphere after adoption of the antiseptic principle.

Two years after the commencement of his experiments with carbolic acid, Lister published an account of the eleven test cases, together with a description of his treatment of abscesses. The paper consisted of several sections, which appeared in the *Lancet* between March and July 1867; in the first section he acknowledged the inspiration he had derived from reading the works of Pasteur, and enunciated the principle upon which he based the practical details. In August of that year he attended the Annual Meeting of the British Medical Association in Dublin, where he read a paper on " The Antiseptic Principle in the Practice of Surgery." In addition to describing the manner in which he conducted an antiseptic operation, and recording several improvements in

his system, he dealt more fully with the principle underlying the treatment than in the previous paper. This afterwards appeared in the *British Medical Journal*. These publications attracted great attention in the medical world, and before long many comments appeared, favourable and adverse. The successes Lister claimed to have achieved, together with the statement that he had discovered a new principle by which the whole practice of surgery would be revolutionised, called for consideration. He could not be ignored. After the medical press, publicity spread through the medium of the morning and evening papers, the weekly and monthly journals. Unfortunately, all but a few confused the discovery of a new principle with the discovery of carbolic acid as a new method of treatment. The non-medical press could be forgiven for this; the technical details of surgery are unintelligible to most people outside the medical profession; but that the *Lancet* should make this mistake seem almost incredible to us. In an article published in that paper during the year, there appeared the following words: "If Professor Lister's conclusions with regard to the power of carbolic acid in compound fractures should be confirmed by further experiment and observation, it will be difficult to over-rate the importance of what we may really call his discovery." Lister did not claim to have discovered carbolic acid as a method of treatment. Carbolic acid was merely the antiseptic he had decided to use in carrying out the new principle of making and keeping a wound

free from invasion by microbes from the beginning to the end of treatment.

Lister then passed through one of those bitter experiences that sometimes overtake pioneers when their ideas come into conflict with prejudice and old-established custom. He was the victim of a spiteful attack that was all the worse for being anonymous; though Lister and many others recognised from whence the criticisms sprang. Lister was in this case deliberately misunderstood, misrepresented, and accused of having knowingly claimed as his own the discovery of another. This was the worst form of persecution to which a scientific man could be subjected. Sir James Young Simpson of Edinburgh, a remarkably clever physician, who could not possibly have mistaken Lister's meaning as to the new principle, made disparaging remarks on the Antiseptic System at the Dublin Meeting. A few years earlier he had introduced a method of controlling hæmorrhage known as "Acupressure," which consisted of passing needles beneath the arteries at the time of operation and exerting pressure upon them, thus causing clotting and occlusion, and doing away with the necessity for ligatures. He claimed that this method would prevent putrefaction. It certainly removed one of the causes of putrefaction, but there were great risks in connection with it. Simpson apparently regarded the Antiseptic System as a rival to his own invention, and he attacked Lister and his ideas from the very first with much energy and uncharitableness. Prob-

ably the fact that Lister was the "professional son" of Syme had something to do with the matter, for Simpson and Syme had waged a war of words for many years. An anonymous letter, signed "Chirurgicus," appeared in the *Edinburgh Daily Review* about a month after the Dublin meeting which was considered, by those competent to judge, to be from the pen of Simpson, who sent copies of it to large numbers of medical men in Glasgow and elsewhere. The writer mentioned an article that had appeared in the *Daily Review* of the day previously, reprinted from the *North British Agriculturalist*. He pointed out that it would bring great discredit upon the English nation because it attributed the discovery of carbolic acid as a method of surgical treatment to Lister, whereas it had been used for many years previously by Continental surgeons, and many essays had appeared upon the subject. He said that he had at that moment a large volume written by Lemaire of Paris lying open before him in which the author very ably discussed the use of carbolic acid in agriculture, hygiene, veterinary practice, medicine and surgery, and its power of destroying microscopic organisms. The Editor of the *Lancet* received a copy of the letter, and soon afterwards this journal had a note upon the matter, from which the readers of the periodical learnt that Lister had not made a new discovery but was appropriating a method of treatment already in vogue on the Continent.

Lister immediately wrote to the *Lancet* pro-

testing against the use that had been made of an anonymous newspaper letter. He had never heard of Lemaire, but he at once procured a copy of the work in question from the Edinburgh University library. He then wrote again to the *Lancet*, saying that he had just read Lemaire's book and had come to the conclusion that the insignificant results obtained by Lemaire were fully explained by the latter's method of using carbolic acid. He pointed out that he had never claimed to be the first to use carbolic acid, and that his successes did not depend upon any specific virtue of carbolic acid. They depended upon "the wonderful powers of recovery possessed by injured parts when efficiently protected against the pernicious influence of decomposition." He thought he might have had as good results if some other antiseptic had been employed upon the same principle. The letter concluded with the warning that surgeons must not expect as good results from carbolic acid as he had experienced unless they applied it with the same scrupulous attention to every detail. He also enclosed a letter he had received that day from Dr. Hair of Carlisle, who, wrote Lister, "seems to have had no difficulty in distinguishing between the mere use of carbolic acid and the practice I have recommended." This gentleman had seen carbolic acid used on the continent and in Lister's wards, and he was in no doubt as to the difference in practice or the greatness of the revolution that Lister had introduced.

Simpson then made an attack upon Lister in the *Lancet*. In a communication entitled "Carbolic Acid and its Compounds in Surgery," he commented upon Lister's ignorance of medical literature, stated that Lister had been preceded by other authors in all his theories about carbolic acid, compared the results obtained from carbolic acid with those from acupressure, and asked why Lister and other surgeons refused to adopt his method of arresting bleeding. But he refused to take notice of Lister's statement that a new principle had been introduced. And with such a powerful man as Simpson arrayed against its inventor, this principle was lost sight of amidst the controversy, so that surgeons came to speak of the "carbolic treatment" and "the putty method," instead of "the Antiseptic System," which grieved Lister very much. Controversy being exceedingly distasteful to him, he refused to continue the discussion, closing the matter with the following dignified letter which appeared in the next issue of the *Lancet*. "The elaborate communication of Sir James Simpson in to-day's *Lancet* may seem to require some reply. But as I have already endeavoured to place the matter in its true light without doing injustice to anyone, I must forbear from any comment on his allegations. In the forthcoming numbers of your journal I have arranged to publish, with your permission, a series of papers fully explanatory of the subjects in question, and your readers will then be able to judge for themselves how far the present attack admits of justification."

Lister's annoyance was great because he had been made to appear in a very unfavourable light before the public, and, in consequence, a new and beneficent invention had received a check at the very outset. He also thought that his articles would do their work more effectively, though more quietly, if editors of medical journals would refrain from comment upon his work in their editorials. In addition to these hindrances, there were other reasons why his notions were not received with that enthusiasm for which he had hoped. Successful surgeons accustomed to other methods of treatment, such as "the moist," "the occlusion," or "the open," saw no reason for a change. They were quite satisfied with their own results, poor as they were, and were unwilling to consider Lister's views. Some attacked the Antiseptic System without even giving it a trial. Others who, whatever they said in public, were secretly perturbed, decided to "give the thing a chance," and as carbolic acid was new to English surgeons, it was the more eagerly taken up on that account. As their attention was fixed upon "carbolic treatment" instead of "the antiseptic principle," their results were extremely poor, whereupon the majority soon returned to their former ways. They merely applied carbolic acid as they had been accustomed to apply other antiseptics, with the same lack of success. These disappointed men were not slow to express their adverse opinions in the medical press and elsewhere, which added to the general confusion of ideas, so that many thoughtful and

conscientious surgeons, who might otherwise have adopted Lister's views, with profit, decided to wait until time had tested the new treatment before subjecting their patients' welfare to an experiment. Thus for several years the Antiseptic System made but slow headway in England, and especially was this true of London. Not until a new generation of surgeons had arrived did the big hospitals of London put Lister's views into practice. In the provinces, where younger men were in charge of wards, it received an earlier start; it had greatest success in the Northern hospitals, where the surgeons were men who had studied directly under Lister and had absorbed his theories and copied his methods.

In the meantime Lister went on quietly perfecting his system, hoping that the constant publication of his improved methods and successful results, together with the reiteration of his principles from time to time, would in the end persuade his professional brethren of the value of his discovery. He received many visitors from all parts of the world who came to his wards in order to learn his methods. Those who really mastered the details found, when they set to work in their own hospitals, that the Antiseptic System accomplished the same marvellous changes for them as it had done for its inventor. From these surgeons, and from those who, after a careful study of his writings, had the intelligence and sincerity to apply thoroughly the principles he taught, Lister received enthusiastic letters and glowing reports. Dr. Bernard of the Naval Hospital gave his

testimony in the Blue Book report regarding the healthiness of the wards under the Antiseptic System of treatment. Dr. Bickersteth of Liverpool, Dr. Pemberton of Birmingham, Dr. Lund of Manchester, and Dr. Cadge of Norwich were amongst his first and most faithful followers. In Glasgow the senior surgeons were against him. All except one tried the new treatment in a superficial fashion and found it a failure. It was not until the younger men took their places that Glasgow became converted, and the same was true of Edinburgh. In Aberdeen, Sir Alexander Ogston (then Mr. Ogston) assimilated the underlying principles, and became so successful that he was able to make many improvements in the art of surgery. Ireland either smiled at or ignored the Antiseptic System, with the exception of a few surgeons. It seemed as if the older men could not understand or accept the teaching of the newly born science of bacteriology, hence their inability to apply successfully the system which was based upon its teaching.

One of the first surgeons to adopt the system on the continent was Professor Saxtorph of Copenhagen University. The large hospital of which he had charge was an extremely unhealthy one, in which hospital diseases were rampant. After a year's treatment he was able to write that there had not occurred a single case of pyæmia. As time went on and he perfected his treatment hospital diseases vanished completely, so that in 1875 he wrote : " I may say that it (the

Antiseptic System) has not modified, but completely changed my principles of pathology and my surgical practice. . . . The word 'hospitalism' no longer terrifies us, and you seldom meet with a case that could be called a case of hospital disease." In 1867, Professor Thiersch of Leipzig adopted the system in his large clinic of 300 beds in the Jacob's Hospital. In the course of twelve months gangrene was entirely abolished and there had occurred only one case of pyæmia. Later on he used salicylic acid successfully upon the same principles, but in the opinion of most surgeons this was not such a reliable remedy as carbolic acid.

One of the most striking testimonials came from Professor von Nussbaum, of the Allgemeines Krankenhaus, Munich. In this hospital pyæmia and erysipelas were prevalent and severe, and hospital gangrene had increased to such a horrible extent that it affected in the last year under the old system 80 per cent. of all wounds, whether accidental or inflicted by the surgeon. The closing of the hospital was being considered when Professor Nussbaum decided to try the Antiseptic System. A few months afterwards he wrote as follows : " Everything that we had tried against the above-mentioned horrors proved unsuccessful. The open method, the occlusion dressing, the continuous water bath, irrigation with chlorine water or with carbolic acid solutions, salicylic acid in powder and in solution, the putting on of Lister's antiseptic materials—carbolic paste, etc.—all, all were unable to combat

hospital gangrene and pyæmia. *But when, in the course of a single week, with great energy and industry, we applied to all our patients the newest antiseptic method, now in many respects improved by Lister, and did all our operations according to his directions, we experienced one surprise after another. Everything went well: not a single other case of hospital gangrene occurred.* Pyæmia and erysipelas were observed a few times at the very beginning; but only, as the result proved, because we did not yet possess the necessary practice in the carrying out of Lister's directions. We took pains, as you know, and learned from day to day more exactly how to comply with his instructions. Our results became better and better, the time of healing shorter, and pyæmia and erysipelas completely disappeared." So complete was the success of the Antiseptic System that the convalescent wards, which previously had been filled to overflowing, now stood empty because the patients recovered so rapidly when spared the complications of hospital diseases.

In Halle, Professor Volkmann, a brilliant surgeon and one of Germany's most versatile men, was in charge of an old and singularly unhealthy hospital. The wards, though small, were overcrowded; water-closets opened into them and a large city drain ran underneath. At one time no surgeon had dared to use a knife in the clinic during the space of three months, even for a minor operation, lest it should end fatally. Returning from the Franco-German War in 1870 Volkmann found the hospital crowded with

wounded soldiers who were in a dreadful state. During the following year conditions grew even worse, so that it was decided to demolish the hospital. Volkmann, however, after reading the publications of Lister, decided to try the Antiseptic System. The change was miraculous, and this unhealthy hospital found itself entirely free from pestilence in a very short time. Volkmann, an impetuous, combative, and artistic man, with literary gifts, became one of Lister's foremost champions. Subsequently he devised many new operations which no one had ever dared to attempt without the protection afforded by the Antiseptic System. Stromeyer, of Hanover, who approved of Lister's invention although he was a great upholder of subcutaneous surgery, wrote two verses concerning Volkmann and Lister, of which the following is his own English translation.

LISTER

Mankind looks grateful now on Thee
For what Thou didst in Surgery ;
And Death must often go amiss,
By smelling antiseptik bliss.

By Volkmann's skill and industry
Famous Thou art in Germany !
Who could a better Prophet be
Than Richard Hotspur was to Thee ?

Many other men in Germany became keen antiseptic surgeons, including von Bardeleben and von Bergmann of the Charité Hospital, Berlin. The latter revolutionised his clinic,

and instead of the old, slovenly methods, he instituted a system of antiseptic drill, which was carried out with military precision to the minutest detail. Holland, Norway, Switzerland and Russia were not far behind Germany. France was slow to accept Lister's teaching, with the exception of four eminent surgeons, one of whom, Lucas-Championnière, visited Lister in 1868 in order to study antiseptic surgery under him. He wrote the first complete French account of Antiseptic Surgery in a small book published in 1876. France generally looked upon Lister's treatment as merely a new kind of dressing, and not as a method of treatment with a new underlying principle. Italy was also slow to accept Lister's views. In Austria the influence of Billroth prevented a thorough trial of the Antiseptic System, though Billroth himself maintained friendly relations with Lister. Americans did not adopt the method until 1877, but when they commenced it was taken up with great enthusiasm and thoroughness. Wherever the Antiseptic System was intelligently applied, the so-called hospital diseases vanished, and surgery advanced in a way that had never before been known.

CHAPTER VIII

In 1866 a vacancy occurred on the surgical staff of University College, and as Lister was very anxious to return to London in order to propagate his views in the capital of the Empire, he allowed himself to be nominated as a candidate for the professorship. He was not selected, however, there being a much more favoured candidate, in the person of John Marshall, already in the field. Lister was very disappointed, but eventually he came to believe that he could make his views better known from a place like Glasgow, where there was one teaching centre and one large hospital, rather than in London, with its numerous smaller medical colleges and varying schools of thought. But in 1869 another opening presented itself. Mr. Syme, who had had a paralytic stroke, resigned from the Professorship of Clinical Surgery in Edinburgh, and Lister was elected in his place. He had an enthusiastic welcome from teachers and students alike, nor was he sorry to find himself once again amongst old friends in the cultured circle of the University where he had first entered upon his surgical career. Some of the most eminent men that Edinburgh has ever known were at that time connected with the

University, including Sir Robert Christison, Professors (afterwards Sir William) Turner, Archibald Geikie and Crum Brown, and Joseph Bell, the reputed original of "Sherlock Holmes." Professor Syme lived only until the following year, which also saw the death of Sir James Young Simpson from angina. The loss of his father-in-law was a great sorrow to Lister, and he wrote for the *Scotsman* an unsigned obituary notice which indicated the high opinion he had always held of this celebrated surgeon. By the death of these professors, both of a combative disposition, the medical world of Edinburgh entered upon a more peaceful phase. Had Simpson lived, many difficulties would have arisen for Lister, who could not easily forget the recent bitter controversy. As it was, he entered upon a fruitful and prosperous stage of his career. His class was large, there often being 170 or 180 new medical students in a year, his students were enthusiastic about his teaching and ideas, and in the University and Infirmary Lister was affectionately called "the Chief" by students and junior surgeons. Whatever theme he commenced to lecture upon, his subject always led up to the Antiseptic System before the end of the allotted time.

Lister was a good lecturer; he gave to his students what no books could supply, he kept his audiences interested, and, above all, he made them think. His lectures dealt with all the many branches of surgery and were enriched with suggestive references to the new knowledge

brought to light by the sciences of pathology and bacteriology. Lister settled in 9, Charlotte Square, a fashionable place of residence and a favourite district for consultants. He soon took Syme's place as the leading Scottish Surgeon, and had a larger practice than at any other time of his life.

If Edinburgh was glad to have him back, Glasgow was not altogether sorry to lose Lister. It was just at that time he published his celebrated article in the *Lancet* "On the Effects of the Antiseptic System on the Salubrity of a Surgical Hospital," in which he recorded the lamentable condition of the Glasgow Royal Infirmary (as described in the last chapter) and the first results of his new treatment. The directors and some of his former colleagues were very indignant, not because Lister had said anything untrue or exaggerated; but the directors did not wish the world to think that their hospital was more unhealthy than others, and his fellow surgeons were naturally concerned for their own reputations. A controversy ensued in the pages of the *Lancet* and the *Glasgow Daily Herald;* statistics were bandied from side to side, and disparaging remarks were made about the novel opinions of both Pasteur and Lister. The hospital directors attributed any improvements there had been to better dietary, ventilation and nursing, and to alterations made after the discovery of the insanitary state of the buildings. In Lister's reply, which was dignified and courteous, he pointed out that his wards had been entirely free from

hospitalism in any form for nine months before the discovery of the insanitary condition of the hospital environment, also that his wards were not affected by the changes in the nursing, for he had had very good nurses from the commencement of his connection with the infirmary, and continued to have such to the end.

In 1915, Sir Hector Cameron in a letter to Sir Rickman Godlee, the nephew of Lord Lister, said: "It is a curious instance of the 'Whirligig of Time' that the present managers consider the old connection with Lister the first feather in their cap."

It was not likely that a surgeon possessed of mental capacities and talents such as Lister's would be content very long with the first clumsy applications of the Antiseptic System, and from the very beginning until the end of his active professional life Lister was busy on improvements of all kinds. The story of the early efforts in Chapter VI sounds very simple; indeed, with our present knowledge, it is impossible for us to realise how hard it was for Lister. His researches necessitated many hours of experimental work in his laboratory, where he often stayed up all night working with chemicals in the search for a perfect dressing, studying the life history of some microbes that had a share in the production of sepsis, or carrying out some physiological experiment. In all his speeches and writings he constantly laid emphasis upon the fact that there was no special virtue in carbolic acid, that the antiseptic system depended entirely

on the principle upon which the use of carbolic acid was based, and that some other antiseptic would probably answer as well. He experimented with many other antiseptics, but found none to equal carbolic acid. This substance was soothing and anæsthetic, it was a powerful poison to microbes even when greatly diluted, it was soluble in all sorts of fluids, it was volatile, and its vapour also was antiseptic.

Though Lister never became an "aseptic" surgeon, as we understand the term to-day, chiefly because he was cautious and therefore hesitated to expose his patient to the slightest danger from chance infection, but also because of the then very rudimentary state of bacteriological knowledge, yet he approached more and more towards that ideal as he gained experience with time. Having found that carbolic acid was an irritant to the tissues, thereby causing damage to delicate cells, he diluted it to one part in twenty of water for application to the interior of a wound. The oily solution (one to four) he kept for the external applications: oil gave up the antiseptic very slowly, and therefore acted as a constant reservoir to the dressing beneath, prevented the germs of the atmosphere reaching it, and if discharges were escaping from the wound they became impregnated with the antiseptic and therefore remained sterile. Surgeons who visited his clinic were astonished to see what appeared to be a lack of cleanliness in the dressing of wounds! They were accustomed to sponge out wounds regularly

with water or other fluids and change the dressings daily. Lister pointed out that asepsis was needed, not cleanliness. Once sepsis had been destroyed by irrigation with carbolic acid, there was no benefit in constantly lifting the permanent dressing with the adherent scab in order to see how the wound was getting on, nor was there any need for lotions and washes to "clean out" the wound. His plan was to leave the permanent dressing and scab severely alone, and to keep microbes away from it by constant reapplication of the upper dressing of putty; Nature could be trusted to do all that was necessary for the healing of the wound if free from germs. More and more he came to see that all the damaged tissues asked for was *to be let alone*. Keep out the germs and do not interfere with septic hands or instruments or anything that can contaminate, and wounds will heal in a straightforward way, was Lister's doctrine.

That was the reason for the protection which he placed immediately over the wound, so that irritation from the acid in the putty might not interfere with the healing processes taking place underneath. Lister had discovered that the acid soaked through the lint which formed the permanent dressing to the scab beneath, and set up the formation of superficial pus, which, though not actually dangerous, was nevertheless undesirable and prevented rapid healing. For this purpose he employed in turn caoutchouc, tinfoil, gold leaf and block tin. Experience showed all

of these to have certain objectionable features, and finally, after many experiments, Lister adopted a protective of oiled silk covered with copal varnish. This was dipped in carbolic acid lotion before applying it to the wound, in order to destroy any microbes that might have settled upon it. The lotion, however, would not adhere to the shiny surface, whereupon Lister had the varnished silk coated with a solution of dextrine and starch, in order to produce a surface that would retain the lotion.

The upper dressing of putty was also found to be objectionable. It was troublesome to prepare and difficult to handle. Lister wanted something lighter and more pliable that would retain the antiseptic for fairly long periods and give it up to the discharges very slowly, and yet would not irritate the tissues. He carried out countless experiments before he found the right medium. He made various plasters from resin and such like substances which proved untrustworthy. A dressing was made of paraffin wax, olive oil and carbolic acid spread on calico, but was soon given up on account of its brittleness. At last he found a satisfactory plaster in shellac. This substance was found to unite admirably with carbolic acid in any dilution, with which it formed a mixture varying from fluid to semi-solid, or solid, according to the varying proportions of the two substances. A thin layer of this mixture spread on calico retained a large quantity of antiseptic for several days at the body temperature and did not irritate. But it possessed

one disadvantage. Its adherent properties made it stick to the skin, a difficulty Lister overcame by lining it with a thin layer of gutta-percha, which allowed the carbolic acid to travel underneath it. Unfortunately, the layer of gutta-percha gave trouble: it had a habit of cracking. Lister, therefore, in order to obviate this, brushed over the antiseptic shellac a very thin film of gutta-percha in bisulphide of carbon. This filmy layer was sufficient to prevent adhesion, but if the plaster was desired to adhere in any part, the film covering that portion could be brushed off.

The following description will give an idea of Lister's usual method of treating a wound until about 1870, when he commenced to use absorbent dressings. After a thorough cleansing of the interior of the wound with carbolic lotion (one in twenty) and approximation of the edges by stitches or other means, the protective, first of tin, but later of varnished silk, sterilised by carbolic lotion, was applied in such a way that it fitted the wound in an air-tight fashion, conforming to the contour of the body, and overlapping the wound to some extent on every side. Over this was placed a piece of the shellac plaster, much larger than the protective, so that discharges, if there were any, might travel a long distance before reaching the exterior. If it was necessary that the plaster should adhere to the skin, as in the case of compound fractures, the film of gutta-percha was brushed off in all directions except one, and

along this outlet, where the plaster did not stick, the discharge was made to travel. In other cases, where adhesion was not desired, the plaster was merely fastened down at the edges with ordinary sticking-plaster. Over the plaster was placed a cloth soaked in the solution of carbolic acid and oil (one-in-four); this was renewed daily for a few days, but afterwards was merely brushed over with equal parts of oil and acid. The cloth soaked up the discharges and acted as a protection to the shellac plaster. This proved a convenient dressing, because the layer of protective and the plaster together formed a thin and pliant covering, which conformed to the contour of the body and did not interfere with accessories such as splints and other appliances. Lister found its action very satisfactory, because, as he said in a pamphlet written in 1870, " An antiseptic (shellac plaster) to exclude putrefaction and a protective (tin or varnished silk) to exclude the antiseptic will, by their joint action, keep the wound free from abnormal stimulus." The protective took the place of the scab (for without the action of strong carbolic acid no scab was formed) and underneath it healing proceeded quietly.

Another great improvement in the art of antiseptic surgery was the introduction of the catgut ligature for the arrest of hæmorrhage. Having found that silk ligatures, if impregnated with carbolic acid, no longer caused putrefaction, Lister took the first opportunity of using antiseptically prepared silk for tying an artery in

the treatment of aneurism. The patient was a lady of fifty-one years of age, upon whom Lister operated in 1868 for aneurism in the groin. He cut down through the tissues and tied the external iliac artery with silk that had been steeped for two hours in strong liquefied carbolic acid and then washed in a one-in-thirty lotion.

The operation was successful, the lady making a perfect recovery, but ten months afterwards she died suddenly from the rupture of another aneurism, this one being in the aorta, and, of course, inoperable. Lister made a post-mortem examination, and was surprised by what this revealed. Contrary to expectation, he found that all the silk had not been absorbed, and that there were signs of irritation of the tissues, including a few pus cells. Fearing lest the use of unabsorbable substances might lead to the development of abscesses, he determined to find a ligature that could be completely absorbed, and it occurred to him that catgut, which from time to time had been used and given up as unsatisfactory, might, if treated antiseptically, answer the purpose very well. Catgut is made from the intestine of the sheep. While staying at Upton House in December 1868, during the last Christmas holiday he spent at home before his father's death the following year, he experimented upon a young calf. The animal was chloroformed in his father's museum, and the carotid artery was tied in two places with catgut that had been soaked for four hours in a saturated watery

solution of carbolic acid. The ends of the ligature were cut short and the wound stitched up at once. The calf, whose recovery and general health had been perfect, was killed at the end of thirty days. At the post-mortem examination it was found that the catgut had been completely absorbed and replaced by healthy new tissue, except the middle of the very thick knot, which evidently required further time: this new tissue, instead of being a source of trouble, strengthened the artery at the place where it had been tied. There were no signs of irritation nor any formation of pus cells. From that time onward Lister used catgut for all internal ligatures; the ends were cut short and left in the wound, which was sewn up immediately the operation ended. He prepared the catgut himself, he always took pains before an operation to see that the ligatures were reliable, and he observed the strictest antiseptic precautions from the commencement to the end of the proceedings. But this innovation necessitated many experiments before catgut became a really trustworthy ligature, and Lister worked upon this subject during the remaining years of his active life. He found that catgut must be old and seasoned in order to do its work properly. The seasoning was accomplished by placing it in a mixture of liquified carbolic acid and oil, which at the same time rendered it aseptic. For ten years this ligature was sold in bottles of carbolised oil and was known as carbolised catgut. Surgeons who obtained bad results with catgut

were usually found to have been using imperfectly prepared catgut or neglecting to take proper antiseptic precautions. Manufactured catgut was often imperfect, and surgeons were unwilling to take the trouble of preparing it for themselves, as Lister did. The time taken for seasoning was from six to twelve months, and longer, though Lister came to learn that over-seasoning was as bad as underseasoning. He set to work to devise means of shortening the time, and in the process of his experiments employed many other chemicals. At last, in 1908, forty years after the original experiment on the calf, he adopted a plan of treating the gut with chromium sulphate and corrosive sublimate. This produced one of the most reliable ligatures ever made and one which is still popular.

By 1870 the further improvement of the Antiseptic System and the introduction of the catgut ligatures had opened up undreamt-of possibilities in the art of surgery. The method of arresting hæmorrhage had been completely changed, and the tying of arteries in their continuity for aneurism and other conditions had now been rendered a safe instead of a hazardous operation. Lister and the men who followed his methods were able to devise and carry out operations formerly regarded as impossible. Visitors to his wards were surprised to find him opening into joints, breaking and resetting badly joined fractures, and performing other operations only made possible by the Antiseptic System. In June, 1867, Lister had successfully performed

a dangerous operation on his sister for the relief of a mortal disease from which she was suffering. No other surgeon of the day would undertake the task. Her brother dreaded the ordeal most terribly, but, believing himself to be the only surgeon in the world who could help her, we are told that, having braced himself for the effort, it was manfully performed. He hoped that he might never have to pass through such a time again. Lister himself never became a great pioneer in the devising of new operations; the remainder of his life was spent in perfecting his system; and it was left to the men who followed in the path he had opened up to introduce the innovations of modern surgical technique.

As mentioned earlier in the book, Lister's first dressing had consisted simply of lint or rag soaked in carbolic acid. This was absorbent. He soon discarded it, inventing first the putty, and later the shellac plaster, which were non-absorbent. The absorbent lint had proved unsatisfactory because it allowed the discharges to soak through; these very quickly became contaminated by the atmosphere, thus rendering the lint no longer sterile. The putty and plasters sterilised the discharges, which were obliged to travel under the non-absorbent material until at the edge of the dressing they were received into a cloth of old boiled linen, which was wrapped round for that purpose. But underneath the impermeable plaster the skin became moist, sodden and irritated from the discharges of the

wound and the natural secretions of the skin. In 1870 Lister heard good reports of oakum, which consists of old rope that has been picked to pieces and soaked in Stockholm tar. As the fibres were thus permeated with the tar it was antiseptic throughout, and decomposition could not spread along the track of the discharges until all the tar had been washed away, which would take a much longer time than is usual for retaining dressings. He gave oakum a trial, placing it above the protective over the wound, and found it excellent, in that it made a good antiseptic dressing, underneath which the skin remained dry and free from irritation; but it was dirty, sticky, and reminded the patient continuously of the dockyard, scenting the atmosphere and flavouring all his food. Lister, therefore, had to find a dressing which would give all the advantages of oakum without its drawbacks. He sought a material that was cheap, one that would be porous and yet capable of being impregnated with sufficient antiseptic material throughout every fibre to resist the effect of the discharges for twenty-four hours. For this purpose he decided to use a very cheap fine muslin, commonly known in the drapers' shops as "butter" or "art muslin." Having secured the muslin, its metamorphosis into a reliable antiseptic dressing was no easy matter; it meant hundreds of experiments before the best medium for the antiseptic was found. It was of no use to dip it into a fluid solution of carbolic acid, for the acid was volatile and escaped from the muslin too quickly

to allow of storage or even a short period of use as a dressing. A successful vehicle was found in a mixture of paraffin and resin, which held the carbolic acid very satisfactorily. The gauze was soaked in this mixture, and when dry packed away in air-tight receptacles. It was an excellent dressing of a pale yellow colour, which smelled not unpleasantly of carbolic acid. Lister applied it as a pad of the thickness of eight layers above the protective on the wound. Between the two top layers he placed a thin piece of mackintosh, known by the clothiers as "hat lining," to prevent the discharges reaching the atmosphere. The yellow hat lining was ordered by Lister to be dyed pink, to distinguish it from the gauze. It is still sold as "jaconet" by the chemists, and is used for covering fomentations to prevent the escape of heat and moisture. As Lister was afraid there might have been evaporation of the antiseptic from the gauze, or that germs might have fallen upon it during its passage from the box to the patient, he commenced the practice of soaking a few layers in carbolic lotion, which he placed next to the skin, immediately above the protective covering the wound. Other methods of impregnating the gauze were tried, none, however, proving so successful until, in 1889, Lister produced one treated with the double cyanide of mercury and zinc. This is the mauve-coloured "cyanide gauze" still in use to-day. Altogether Lister worked at the subject of gauze dressings for a period of forty years, and carried out numberless researches, physical, chemical,

biological and physiological, before the gauze dressing was perfected.

The earliest inventions pertaining to a new discovery are usually clumsy, and of a primitive nature: the first motor-car was very different from the finished product of to-day. As we have seen, Lister's earliest methods have much the same relationship to modern surgical procedure; but the clumsiest, the most whimsical and the most annoying of all his early inventions was that of the famous "carbolic spray." Pasteur's discoveries had directed attention to the effect of the atmosphere upon wounds, and so also had the experiments of Tyndall, which cannot be related here. Lister was so afraid lest microbes from the air should fall upon a wound during the course of an operation that he decided in 1870 to purify the atmosphere in the immediate neighbourhood! He did this first of all by means of a spray, somewhat similar to the ordinary scent spray, which was filled with a solution of carbolic acid lotion (one in forty). It was the duty of an assistant to squeeze the rubber ball and produce a cloud of fine vapour of lotion all round and about the wound whenever the slightest change of dressing took place, though Lister pointed out that it was just possible for a surgeon to work the spray with his left hand while he changed the dressing with his right. A foot spray was then invented, which was worked with a pedal and bellows, and whenever an operation was in progress a succession of assistants was needed, the process being

an exhausting one. Lister's next invention stood upon a tripod and was worked by a long handle. This was a clumsy machine, popularly known as the " donkey engine " ; whenever it accompanied Lister to a private operation this spray was conspicuous to the public owing to the projection of part of the machine through the window of his brougham. The last spray was worked by steam: this appliance sent a fine cloud of carbolic vapour in all directions, causing the atmosphere of the operating theatre to become very unhealthy for patients and doctors alike. The hands of the surgeon frequently became white, and numb, and many doctors could not stand its effect upon their lungs and digestive organs. Lister admitted that the spray was a great evil, " a necessary evil incurred to attain a greater good," but he was afraid to work without it. It must have been extremely bad when operations were being performed in rooms illuminated by gas. Many cases of post-operation sickness in the patients must have been due to it. The poor unconscious patient on the operating table could not give voice to his opinion of this antiseptic cloud, as many of the doctors did. Yet the carbolic spray was used by Lister, and by doctors all over the world for many years, and though some surgeons, who used all the other antiseptic measures except the spray, achieved quite as good results, Lister obstinately clung to this appliance. He reduced the strength of the lotion to one in a hundred, but later returned to the one-in-forty solution, and ceased to irrigate

the wound while the spray was working. Consequently, though the vapour was constantly falling upon the wound from the air, less carbolic acid was entering into the tissues. Lister, who was one of the last to abandon this invention, finally gave up using it in 1887, for the following reasons:—

1. Antiseptic surgeons got excellent results without it.

2. Lister came to learn that certain parts of the body, such as the peritoneum and the face, possessed very powerful defences against microbes. This explained the good results obtained by Spencer Wells and Thomas Keith, the gynæcologists, both clean and careful, though not antiseptic surgeons, who had reduced the mortality after cases of removal of the ovary to 16 per cent. Keith had tried the spray, with great success, obtaining eighty recoveries in an unbroken series with its aid, but he gave it up again. Lister thought that if the peritoneum could deal so effectively with the microbes of the atmosphere, the other parts of the body might also act in like manner. But for a long time he was too cautious to discontinue the use of the spray, feeling that it was right to use every means at his disposal to safeguard the health of the patient.

3. From the researches of Metchnikoff Lister learnt of the marvellous behaviour of the white cells of the blood, the so-called phagocytes whose function it is to destroy microbes. He feared lest the antiseptic of the spray should hinder the activities of these delicate cells.

4. The new science of bacteriology began to discriminate between harmful and harmless germs. The microbe population of the air consists chiefly of non-pathogenic bacteria, yeasts and moulds, which float about adhering to particles of dust. Disease-producing germs do not live long in the air and often lose their virulence in situations other than living tissues. The patient's skin, the surgeon's hands, instruments, towels, sponges, ligatures, and anything to which discharges and filth could adhere in small quantities, unseen even after washing, wherein germs could multiply freely, were the principal source of infection in pre-antiseptic days.

Lister was never unwilling to admit his mistakes. After seventeen years of vigorous championship of his "carbolic spray," during which time there had been many critics, scoffers and doubters, many hard battles, and a decreasing number of supporters of this particular part of his treatment, he expressed the opinion that it had all been unnecessary. By the ignorant and by those who never could or would understand the principles, the Antiseptic System was referred to during those years as "the spray and gauze treatment."

CHAPTER IX

In 1871, Lister, then Surgeon-in-Ordinary to Her Majesty in Scotland, was called to Balmoral to operate upon Queen Victoria, who was suffering from an abscess in the arm-pit. When moving the adoption of an address of sympathy and loyalty from the Royal Medical and Chirurgical Society on the accession of King Edward in 1901 Lister said, "I believe that I happen to be the only person who ever exercised upon her sacred body the divine art of surgery. The occasion was a most critical and anxious one, but, while she treated me with queenly dignity, nothing could exceed her kindness." Lister stayed a week at Balmoral, though the case apparently was simple and straightforward. Sir William Jenner worked the carbolic spray and by accident some of the irritating vapour entered her Majesty's eyes, doubtless causing pain and annoyance. She complained of this, whereupon Sir William excused himself, saying that he was "only the man who worked the bellows." The Queen afterwards complimented Lister on "a most disagreeable duty most agreeably performed."

It was during this little operation that Lister

made another innovation in his treatment. Drainage had always been an important part of the antiseptic treatment on account of the watery discharge produced by the irritating chemical action of carbolic acid, which, though free from sepsis, had nevertheless to be drained away. For five years Lister had used strips of carbolised lint for this purpose. When changing the dressing the day after the operation on Queen Victoria, he found such a quantity of thick pus that he improvised a drainage tube from the india-rubber tubing of the carbolic spray. He took a portion of the tube and cut holes in the rubber at short intervals along the whole course of it; the end was cut obliquely so that it might be on a level with the skin, and two silk threads were threaded through in order to tie the tube to the limb. This was steeped in strong carbolic lotion for a night and placed in the wound the next day. It resulted in such successful drainage that Lister adopted rubber tubing from that time forward, and eventually other surgeons came to recognise its advantages. In the aseptic surgery of to-day drainage is not often required; when it is necessary, rubber tubing is frequently used. Before Lister, Chassaignac was the only surgeon who had ever used rubber tubing, but his work was almost unknown in this country.

Lister constantly experimented with new antiseptics, and it is to him that we are indebted for the boracic lint so commonly used for fomentations to-day. He had heard that boracic acid

had been successfully employed for preserving meat and commenced to use it as an antiseptic for wounds in 1871. This substance is soluble to a greater extent in boiling water than in cold, a factor which enabled Lister to introduce a much larger quantity of the antiseptic into the meshes of the lint than would otherwise have been possible. Therefore the discharges from a wound, which never reach a temperature of more than 100° F., could not wash away the whole of the acid during the twenty-four hours that Lister allowed the dressing to remain in place. This appeared an "ideal" dressing. It contained a large reservoir of a non-irritating antiseptic, which exercised a soothing action upon the part to which it was applied, though its germicidal powers were afterwards found to be not as great as those of carbolic acid.

Throughout the whole of his active professional life Lister engaged in bacteriological researches in his spare time. Whenever he moved from one residence to another, one room was at once commandeered for a laboratory, and to this he transferred his apparatus, his chemicals, his microscope, and his cultures of bacteria and fungi. Many of these bacteriological researches were carried out in connection with his antiseptic experiments, but others were undertaken as a hobby, Lister having conceived a great love for the science inaugurated by Pasteur. When he died he left many notebooks filled with bacteriological notes and hundreds of delicate camera-lucida drawings illustrating his experiments and

observations. Like all pioneers, he constantly went astray, but this did not deter him; he acknowledged his mistakes when he discovered them, and persevered in his researches. It is impossible in a small book to do more than mention a few of his contributions to bacteriology. Some of his conclusions have since been proved wrong; some were disproved by succeeding bacteriologists and later acknowledged to have been right; while others are still sub-judice. He worked with the simplest of apparatus, most of which he designed himself, and as he freely described his inventions in his publications, they were soon adopted by other bacteriologists. Laboratory workers of to-day are indebted to Lister for much of the technique and apparatus still in use. He invented and brought to perfection—as far as was possible in fluid media—a method of preparing pure cultures of bacteria, which was employed by bacteriologists until Koch introduced solid media. To him are due the glass cover plates for keeping away the dust and microbes from cultures, also the "Hot Box," the forerunner of the modern hot air oven, which gave a uniformly diffused dry heat of 300° F., in which he sterilised his glass tubes and other apparatus. Milk was then a favourite medium for the cultivation of germs, and Lister, having found that this fluid was difficult to sterilise, devised a method for overcoming this difficulty. Dr. Burden Sanderson had published a paper which set out to prove that bacteria were carried by water, but not by air; that the air

carried fungi, but not bacteria; and that bacteria were killed by drying them at a temperature of 100° F. This was contrary to Lister's views. What was the use of his antiseptic spray if the air was free from bacteria? It was not long before he disproved these statements. He took a sterilised wine-glass into the street and allowed a few drops of rain to fall into it, after which he filled the glass with sterile unboiled urine. He also exposed some of the urine in another glass to the air in his study. Very soon there was a growth of fungi, yeasts, and bacteria in each glass. This little experiment is an example of the simple and direct manner in which Lister's mind always set to work. He then commenced to study the life history of the organisms of the air, and though some of his conclusions were proved later to have been incorrect, at least two are noteworthy and are to-day recognised as true. One was that the form and fermentative energy of microbes changed with the different media in which they were grown and the varying circumstances to which they were subjected. He therefore started a series of investigations into the life-history of these organisms under varied conditions. The second conclusion was that there might be decomposition of an albuminous liquid without the smell usually associated with putrefaction. This led him to realise that there might be other diseases due to microbes in addition to those which gave forth the characteristic smell of decay. Reasoning in this way he came to talk of *infection*, and not only of putrefaction. His

next researches were concerning lactic acid fermentation in milk, about which he wrote to Pasteur; a scientific friendship developed between the two men lasting to the end of Pasteur's life. In his reply, Pasteur expressed great surprise that Lister could devote himself "to researches which demand so much care, time, and incessant painstaking," while acting as surgeon to a great hospital. Had Pasteur known of the multitude of further experiments that Lister never mentioned or published he would have been still more surprised.

In 1875 Lister paid a visit to those hospitals on the Continent, chiefly in Germany, where his Antiseptic System had been adopted. Everywhere he was received with great enthusiasm, banquets and fêtes were given, together with the usual speeches and toasts of health, and he was honoured by the presence of the King of Saxony at an operation in the Leipzic hospital theatre, during which it was explained that but for the Antiseptic System that particular operation could not have been performed. At the Leipzic banquet Professor Thiersch, in a complimentary speech full of dry humour, said that Lister's discovery, like all great discoveries, had passed through the usual three stages: "the first when the world smiles and shakes its head and says "'That's all nonsense'; the second, with a shrug of the shoulders and a look of contempt, 'It's the merest humbug'; and finally, 'Oh, that's an old story; we knew that long ago.'" That might have been true of Germany; but

England in 1875 had certainly not reached the third stage. Altogether the tour, which became something like a triumphal march, was a great success, and had Lister developed a sense of his own importance he might have been forgiven in view of the warm reception he received. But his own country saw to it that his head should not be turned with flattery—not that this was likely with such an unassuming character—for it was many years before he received the acknowledgment that was due to him in England.

In the same year Lister received a letter from Queen Victoria asking him to make some public declaration against what she styled " the horrible practices " of vivisection in view of the forthcoming activities of the newly appointed Royal Commission. Lister replied that such experiments were not " horrible "; that they were much more merciful than customs countenanced in the name of sport, or of animal breeding and training, or for the purposes of providing food; and he believed that vivisection, carried out, as it usually was, under an anæsthetic, was absolutely necessary if mankind was to be delivered from the effects of disease. Therefore he could not conscientiously accede to Her Majesty's wishes. This attitude Lister maintained to the end of his life, during which he often appeared as a public supporter of vivisection. He himself was a great lover of animals, and this gentle and sympathetic man, so greatly beloved by his patients, to whom, in their hour of need, he proved himself the strongest and tenderest friend,

could not have given expression to such views without the honest conviction that he was right.

A visit to the Philadelphia International Medical Congress in 1876 was the stimulus which prompted the first trial of the Antiseptic System in America. Lister was "one of the heroes of the occasion," and was made president of the Surgical Section; on the second day he spoke for two and a half hours and was then questioned as to details, to which he replied, and spoke for another hour. From which we may conclude that he interested his audience! One of the American reports read, "Modesty is stamped upon his every act and word, but he *does* believe in antiseptic surgery!"

Some men's ambitions are not realised until it is too late for them to experience elation. Life had been kind to Lister, and although he was fifty years of age when his early desire of becoming a London professor was fulfilled, he was still young for a surgeon; but the motive that brought him to London then was different from that which prompted him, at the close of his student days, to seek a career in the metropolis. In exchanging a post at that great centre of medical education in Edinburgh—with its cosmopolitan crowd of students and foreign post-graduate visitors—for a less conspicuous position in a small London hospital, Lister was inspired only by a single aim. The Antiseptic System had been adopted in almost every part of the enlightened medical world with the exception of London. At last came the opportunity of letting

the Londoners see how he actually carried on the treatment. Although his invitation to fill the chair of Clinical Surgery at King's College Hospital in 1877 was not unanimous and was the cause of much misunderstanding regarding Lister, and although Edinburgh made great efforts to keep him, as a man with a mission he knew he must accept. He soon found, however, that the Londoners were anything but anxious to be converted, and the reception accorded by King's College Hospital to the apostle of antisepsis could hardly be described as hearty. The two small wards capable of holding only twenty-four patients were totally empty, so that no cases were forthcoming for his first clinical lecture until, at the last moment, there appeared a poor patient in an advanced state of consumption. Most of his future colleagues on the staff did not believe in his principles, and the nursing sisters, on whom depended, to a great extent, the success of his treatment, were either unenthusiastic or hostile to his methods. The Introductory Lecture of the Autumn session, given by Lister to the entire school, including the staff, was a splendid opening to the London campaign against sepsis, his subject being "The Nature of Fermentation," the foundation of the Antiseptic System. As the weeks went by, however, the four house surgeons who had accompanied him from Edinburgh wandered about the empty wards, experiencing a sense of desolation, and wondering at the apathy and indifference to the message which had brought

their " Chief " from his large and busy Infirmary in the North and his enthusiastic class with its hundreds of eager students to this atmosphere of chilly neglect. They strolled through wards in King's and other hospitals where " the air was heavy with the odour of suppuration, the shining eye and flushed cheek spoke eloquently of surgical fever." The twenty-four beds were filled after a time, but the surgical class never became worthy of the name to these young men so fresh from other scenes. The students were listless and few in number. Never again was Lister to experience that bracing sense of exhilaration that comes from facing a large and interested audience. The London students did not meet their own teachers in the examinations, and they were much more concerned to hit upon the right answers to the questions that would be asked at examination time than to give rein to their natural curiosity and enlarge their outlook by becoming acquainted with the newest ideas. For a time the class increased, but the students soon found that if they gave Lister's ideas or suggested his methods at examinations they failed to pass. Soon the class consisted chiefly of those whose surgical examinations were over and who came for the purpose of enlarging their knowledge. For years Sir Watson Cheyne, an old student and follower of Lister, attended the class himself to increase the number because his teacher felt the change from Edinburgh so keenly. Lister's personal relations with his colleagues, whatever they thought of his system, were cordial ;

one of them, who was quite friendly to Lister, said that his fame came from Germany: that "the Germans were dirty people," and the Antiseptic System "was not really necessary in England." For a long time the surgeons of London remained scornful and sceptical. When, during his first month in London, Lister performed an operation to wire together a broken kneecap, an eminent surgeon is reported to have said, "Now when this poor fellow dies, it is proper that someone should proceed against that man for malpraxis." The man did not die, in fact he did not even develop the fever so common in the practice of this eminent surgeon. As time went on, and more and more difficult operations were as successfully performed, London became interested and began to think there must be something in the Antiseptic System, after all! The cases were there in King's Hospital and could be seen by anyone who cared to pay a visit; this did more towards establishing the system in London than all the reports and statistics that had hitherto been published from Edinburgh. Moreover, the London surgeons found in Lister, not the bombastic person they had imagined, always pushing forward his own claims to recognition, but a humble-minded, courteous gentleman, ready to initiate others into his secrets, and only anxious that suffering humanity should have the full and immediate benefit of his discoveries.

Lister and his wife made their home at 12, Park Crescent, which was not in the consulting

quarters, but Lister preferred to have gardens close at hand, wherein he could walk daily and meditate upon his work. His London private practice became considerable, but never as large as the one he had in Edinburgh. It was unique, however, in that it consisted very largely of patients who were sent to him from all parts of the world in order that they might have the benefit of the antiseptic treatment. His election to the General Medical Council in 1876, an acknowledgment that he was then considered to be the greatest surgeon in Scotland, had been followed by an invitation to address the Pathological Society in London. After he settled in the metropolis such invitations were frequent, and whenever Lister gave an address or lecture he always took the opportunity to bring before his audience some aspect of the Antiseptic System, or the principles upon which it was based.

It was not Lister's work at King's College, nor his teaching, nor his public and scientific addresses, nor even the succession of the young men who had adopted his views to positions of responsibility that brought about the final capitulation of London,—though all these had their part. Professor von Bergmann, of Berlin, of whom mention has been made in Chapter VII, was a clever, original and versatile man, who only entered the profession of surgery after the Franco-Prussian War because he saw that the Antiseptic System would open up a field of tremendous possibilities for an ambitious surgeon.

He very soon realised, however, that Asepticism would become the system of the future, and that Antisepticism was only a transition stage. An aseptic dressing is free from germs, but there is nothing in it to kill microbes or inhibit their growth, should they enter from the atmosphere. Although Lister may be said to have originated the aseptic wound, he had never dared to try to reach his ideal by any way other than that of antisepsis. When he had placed a piece of varnished silk immediately over an aseptic wound to protect it from the irritating effect of the carbolic acid, that was as far as he dared go, and he thought it neither wise nor safe to place above the protective a dressing that was aseptic only. And, indeed, it would have been unsafe for him to do so, for after the use of carbolic acid lotion in the irrigation of wounds there was always a certain amount of serous discharge which, though sterile when it was formed, would very soon have become septic had it travelled through a dressing which contained no antiseptic properties. Von Bergmann carried Lister's system a step further, and after elaborating the details, evolved a system of "*Aseptic Surgery*," which, later on, was described in a book by his assistant, Dr. Schimmelbusch, and became the model for modern surgery. His fame spread abroad, and surgeons from England and elsewhere visited Germany to see the gorgeous new operating theatres that were coming into existence. Of himself von Bergmann said at a banquet on his sixtieth birthday: "I have been no heaven-

storming pathfinder. . . . I have not placed myself in the rank of a Lister or a Billroth. . . . If I have accomplished anything, it has been in the way of critical repetition and improvement."

When Lister's teaching came back to London, elaborated by German inventions and almost unrecognisable because of the accompanying paraphernalia, it was received with open arms; and before long surgeons were busy comparing the merits of the Aseptic System versus the Antiseptic System, much to the disadvantage of the latter. Many of them failed to realise that the object the two systems had in view was the same, and that if only they had accepted Lister's teaching in his early days they might have attained that object a generation previously and thus have prevented much suffering and many deaths in the meantime.

Lister did not approve of the newer methods. They seemed to him to be very complicated and only to be carried out successfully in well-designed operating theatres. He failed to see how aseptic operations could be satisfactorily performed in private houses by doctors who had to rely upon commercial firms for the sterilisation of their gowns, gloves, towels and dressings. For his own system he claimed that it was reliable and simple, and could be carried out equally well in the operating theatre, the private house, or on the battlefield. It aimed at producing an aseptic wound by the use of chemicals, by destroying the germs already present in the wound, and by preventing the entrance of live

germs during the operation and afterwards. When Lister conducted an operation there were provided several trays and bowls containing carbolic acid lotion of two strengths, one-in-twenty and one-in-forty. The clean instruments were placed in one of the trays containing a one-in-twenty lotion in which they lay immersed for twenty minutes to half an hour. Clean sponges, which between operations were kept in a one-in-twenty lotion, were placed in a bowl of one-in-forty solution. While the patient was receiving the anæsthetic the skin over the site for operation was cleansed with one-in-twenty carbolic lotion; this was the only preparation the skin received, because Lister considered that the hair and greasy matter of the skin had a great affinity for carbolic acid, therefore he would allow of no washing with soap and water immediately beforehand. Having taken off his coat, pinned an ordinary clean, unsterilised towel round him, and fastened up his shirt sleeves, Lister commenced the operation. He wore neither mask nor gloves. He washed his hands in a one-in-twenty carbolic solution, or in a mixture of one-in-twenty carbolic acid and one-in-five hundred corrosive sublimate lotion. Towels wrung out of the one-in-twenty lotion were placed in position over thin mackintosh all round the wound. During the operation the assistant doctors and nurses frequently washed their hands in one-in-forty carbolic solution; the sponges, as they were used, were washed in cold and hot water and replaced in the one-in-forty solution, and before sewing up

the wound Lister washed it out with a solution of one-in-forty. This last was a precaution against the possibility of contamination by carelessness on the part of any assistant. Thus, by the use of sponges and the final irrigation, the wound received a fair quantity of carbolic acid. The ligatures of sulpho-chromic catgut were prepared by Lister himself, and these and the sutures of silver wire, gut or silk were rendered antiseptic by immersion in one-in-twenty carbolic lotion. Next to the wound was placed a pad of gauze wrung out of one-in-forty lotion, over this a pad of dry cyanide gauze, and covering the whole was a mass of salicylic acid wool, which lay underneath the bandages.

The Antiseptic System had two drawbacks. One was the irritating action of carbolic acid and other chemicals upon the patient's tissues; the second was the equally irritating action upon the skin of the surgeon's hands, which became numbed at the time of the operation, and afterwards rough and chapped.

The Aseptic System recognised the ability of the patient's tissues to deal with the few microbes from the air entering the wound during the operation; it dispensed with all irritating chemicals; and it guarded against the introduction of contamination by the use of steam-sterilised instruments, dressings, ligatures, gloves, towels, and gowns, which were all rendered aseptic, but not antiseptic. What Lister's simple teaching and methods could not accomplish in the minds of his contemporaries, the foreign marble theatre,

with its silver-plated operating tables, steam sterilisers and revolving drums, soon succeeded in doing. The sight of the surgeons clad in sterilised caps, masks, overalls and shoes, perhaps after a preparatory bath in an adjoining room, scrubbing their hands to the timing of an hour-glass, was an intriguing spectacle to visitors! Naaman's comparison between the waters of Jordan and the rivers of Abana and Pharpar and the reply of his servant may not be out of place here. Everybody was immensely impressed, the pendulum swung far in the opposite direction, and in a few years scarcely a hospital remained in England but had its up-to-date operating theatre. This was all to the good, for at last surgeons realised that sepsis had to be guarded against, and in acquiring these new, if somewhat expensive habits, the old dirty methods were forgotten or looked back upon with horror, and the end that Lister had in view was accomplished.

Modern operative surgery may be described as a combination of the two systems. Where wounds are already septic it is necessary to use some form of antisepsis first of all in order to create an aseptic wound. In the Great War, aseptic surgery failed to deal effectively with the lamentable conditions met with on the battlefield. Then various forms of antiseptic surgery were tried. Finally, it became the opinion of most surgeons that complete excision of the wound, followed by measures to prevent the further entrance of microbes, was the best method of dealing with the wounds of war.

The aseptic system gives the best results in wounds inflicted by the surgeon for the purpose of operation, though even here certain antiseptic precautions are taken. The skin of the patient is usually cleaned with an antiseptic such as tincture of iodine previous to the operation. The overalls and gloves of the surgeons and nurses, the swabs of gauze which take the place of sponges, the towels and dressings are all rendered aseptic by being sterilised by steam in powerful autoclaves. Hands are cleansed either by scrubbing with soap and water, or by using some antiseptic, after which sterile rubber gloves are drawn on. Instruments are boiled and then placed in cooled boiled water or on a sterilised towel. Sharp knives, scissors and needles are sterilised in pure carbolic acid or some other powerful antiseptic. The aseptic towels are fastened by clips to the edge of the wound after the incision is made, and during the operation the aim of the surgeon is to manipulate the parts as little as possible and to introduce nothing that will irritate the tissues. Collections of blood are merely wiped away with the aseptic swabs, no lotions or washes being used, except on rare occasions when a douche of sterile water or salt solution is necessary, after which the wound is wiped as dry as possible. Catgut, silk or linen ligatures are used, all preserved in a sterile state. The dressing usually consists of a pad of dry aseptic gauze and cotton wool. The pad must be thick enough to prevent any discharge percolating through to the atmosphere before the

dressing is changed. After an operation of this kind there is usually very little or no serous discharge, and often the stitches are taken out of an aseptic and perfectly formed scar at the end of seven or eight days.

CHAPTER X

LISTER's dignified and charming personality, the outward expression of a character embodying those attributes most esteemed, coupled with his rare intellectual gifts, soon overcame any personal opposition there may have been towards him in London before he came to live there. In a short time his circle of friends was a large one, and we are told that he had a wider dining acquaintance amongst the leaders of the medical profession than many who had spent the whole of their professional lives in the capital. Even those who did not approve of his doctrines could not help liking the originator of them. As the years passed by it became recognised, both by the profession and the public, that he was the greatest surgeon the century had produced, and honours, British and foreign, were showered thickly upon him, far too many to be mentioned in this book. Long before he died he had become a national hero, and an object of world-wide respect. It is not given to many benefactors of mankind to receive such overwhelming acknowledgment of their services as did Lister; his early days were happy in the consciousness of a creative effort that might bring mitigation of suffering to countless numbers of his fellow-creatures; his old

age was lightened by the knowledge of success and the chorus of gratitude from a thankful world.

In 1878, soon after coming to London, he was appointed Surgeon-in-Ordinary to Her Majesty Queen Victoria, on the death of Mr. John Hilton. The baronetcy which was bestowed upon him in 1883 was considered by some to be long overdue, and rumour had it that this honour had previously been offered and refused, or that it had not been offered earlier because his views on vivisection were not approved by Her Majesty. Neither of these rumours was true. While men of other professions, not to mention those engaged in commerce, were frequent recipients of such honours, baronetcies, for some reason, were then seldom bestowed upon members of the medical profession. There were at that time only four doctors in possession of the title, one of whom was a surgeon. Perhaps it was because, until late in the eighteenth century, the surgical profession had consisted largely of apothecaries and barber surgeons who were considered as too lowly an order for royal favour, and custom had been slow to change. As if anxious to make up for past neglect, however, the Crown bestowed four other baronetcies upon doctors in the year 1883. Great satisfaction was felt by Lister's followers at the distinction conferred upon their leader, while Lister himself, who had always been impressed with the undesirability of men of science engaging in an undignified scramble for titles, regarded it as a tribute to the value of his

Antiseptic System and nothing more. He went on quietly with his experiments, making no change in his mode of living, and filling his laboratory with more and more apparatus and his notebooks with observations upon all kinds of scientific matters that had a relationship to the principal work of his life.

How Lister managed to find time for all these researches will always be a mystery; for wherever he lived he was drawn into the ordinary academic and business life of the college and hospital; he read papers and lectured before learned societies, medical congresses, and conventions; he presided at committees and gave evidence before commissions; he was a member of various councils; he gave dinners and receptions; and, in addition, he had the hospital work and private practice which most surgeons find quite sufficient in themselves. Perhaps he had learned in his early Quaker days the secret of never wasting a moment in unproductive thought or labour, and he certainly had in his wife a partner who could always be relied upon for the conscientious performance of a prodigious amount of what some would consider to be drudgery. Lister was the first Chairman of the Governing Body and afterwards became President of the Jenner Institute, later known as the Lister Institute, taking an active part from the first in the founding of this important undertaking, which was, in the end, guaranteed financial stability by the gift of £250,000 from Lord Iveagh. In the large building on the Chelsea Embankment very valuable research

work is carried on in the sciences of bacteriology, bio-chemistry, proto-zoology, experimental pathology, in the study of disease and public health in general.

One of the most interesting functions that Lister ever took part in, and one that, perhaps, brought sadness with it, was the commemoration of Pasteur's seventieth birthday in the Sorbonne, where all the world met to do honour to the great savant who had discovered so many secrets of Nature and wrested from her some of the mystery of her cruel tyranny over mankind. At the conclusion of Lister's address the Master, now broken in health and worn out by incessant toil, rose to embrace his illustrious pupil before the large assembly. This dramatic scene has been portrayed in the well-known picture by Rixens, and is thus described, "The embrace of these two men was like a living picture of the brotherly unity of Science in the relief of mankind." The sight of Pasteur, enfeebled and past all further participation in the engrossing work of scientific research, must have awakened feelings of sorrow in the heart of Lister, and at the same time reminded him, that, healthy as he was, he was only five years younger, and the time remaining to himself for all the work he still had in view was growing very short.

The year 1892 also saw the retirement of Lister from the Chair of Clinical Surgery at King's College Hospital, in accordance with the rule that professors must retire at the age of sixty-five. At the conclusion of his last clinical

lecture at the end of July, which was reported to be "an excellent résumé of the present aspects of the essential parts of the antiseptic treatment of wounds," "he spoke with some degree of sadness of the termination of his course as a lecturer, and expressed to the students the hope that in the practice of their noble profession their main object would be to promote the good of their fellow men." He was asked to continue the supervision of his wards for another year, which postponed the feeling of complete superannuation. At the end of the year he also gave up his private practice, feeling that it was not fair to his patients to continue this work when he no longer had the opportunity of gaining constant new experience such as can only be obtained by frequent daily operations in a large hospital. There was one consolation, not a small one, in his retirement; he looked forward to the occupation of his time in further researches, and in the collection and edition of some of his earlier work that had never been published.

In the spring of 1893 Lister and his wife were spending a holiday at Rapallo, at the southern end of the Italian Riviera. When they had been there about a week Lady Lister was seized with a shivering fit, acute pneumonia developed, and in four days she died. Lister was all alone with her to the end. He was without a nurse or an English doctor to advise him, but the Italian doctor, Piaggio, took a room next to that of the Listers and gave all the help he could; but in such a case nothing but careful nursing is of

much avail. The shock to Lister at the loss of his beloved comrade was terrible. All alone he had to make the sad journey back to England, bringing with him the body of the wife who had been everything to him for thirty-seven years. The homecoming to the large, empty house, devoid of children, was desolate indeed, and from that time the whole course of Lister's life was altered; he became a sad and lonely man without the presence of the woman who had been both wife and mother to him, who had shared his anxieties and his triumphs and followed his career with thoughtful care. Although his sister-in-law, Miss Syme, continued to live with him, there were no more bright social gatherings in his home. The experimental researches that recalled so vividly the radiant and happy presence of the one who had done so much to inspire him were neglected, the entries in his notebooks became fewer and fewer in number, and after 1896 they ceased altogether, so that most of the work to which he had looked forward on his retirement was never accomplished. He could not even bring himself to edit the papers containing the accounts of his earlier scientific work.

The scientific men, as distinguished from the purely medical fraternity, were the first to pay honour to Lister, and long before his Antiseptic System was estimated at its true valuation by the doctors, the pure scientists had expressed their sense of its great importance. When he was only thirty-three years of age, before he invented the system, Lister had been made a Fellow of

the Royal Society, which is, after all, the greatest honour that can be bestowed upon a scientific man. The Royal Society is a most exclusive body, where the medical men are in a small minority, and it never honours any man unless his work is of great and outstanding merit. In 1893 Sir Archibald Geikie retired from the office of Foreign Secretary, whereupon some of the more influential Fellows, seeing that Lister was in a very sad and depressed state, nominated him as successor. He felt too broken to consider the appointment, but at last he changed his mind and was elected in the November of that year. This was the best thing that could have happened for Lister at that time. It introduced him to a fresh field of interest, in which correspondence with eminent foreigners and visits to other countries had their part, and he continued to act as Foreign Secretary until he became President in 1895, after the retirement of Lord Kelvin. He was President for the usual term of five years. Before his appointment, only one surgeon had held this office—Sir Benjamin Brodie. We learn that this position was a source of great gratification and pride to Lister, as well it might be, for he presided over the most distinguished and learned body of men in the kingdom. He never forgot, however, that he was a doctor as well as a scientist and always took the doctor's point of view in scientific discussions. From the death of Lady Lister, until illness incapacitated him in 1903, Lister was a public servant, taking part in numerous scientific discussions, entering into

correspondence concerning matters of public health, advising the Government whenever his expert opinion was needed upon the questions of the day, and aiding with sympathetic interest and advice the younger men engaged in the scientific research he no longer felt himself equal to undertaking. In the autumn of 1894, the portrait by Ouless, which now hangs in the front hall of the College of Surgeons in Lincoln's Inn Fields, was presented to him by the Fellows and Members of the College. Another portrait, by Lorimer, presented at King's College about the same time, may be seen in the Library Hall of Edinburgh University, and a copy of this picture was afterwards made for Glasgow University. We are told that Lorimer's portrait presents too sombre an impression of Lister, who never was guilty of such a gloomy expression even during the saddest experiences of his life. Copies of Ouless' portrait, which is considered to be a satisfactory likeness, are to be found in the Lister Institute and at the House of the Royal Society. These two were the only portraits painted of him during his lifetime. The bust at the Royal College of Surgeons and the medallion in Westminster Abbey, both the work of Sir Thomas Brock, and executed after Lister's death, are considered to be excellent.

When the New Year honours of 1897, the year of Queen Victoria's second jubilee, were published, Lister's name was found among the list of new peers. This announcement was received with great delight, for it was generally

felt that Lister was more than worthy of being the first medical man to be raised to the peerage. The medical men in particular were pleased, and took it as a sign that the medical profession was now to receive the same recognition as had been bestowed in the past upon members of the fighting services, dignitaries of the Church, and eminent lawyers. But this was a mistake on their part, for Lord Salisbury had made it clear in his letter to Lister that the considerations which had actuated the bestowal of the honour were those pertaining to Science rather than to Medicine. He mentioned the extraordinary services that Lister had rendered to Science, "and especially to the beneficent science with which you are professionally associated," and he ended by saying, "I have no doubt that it will be received with approval by the distinguished men over whose scientific labours you preside," this being a reference to Lister's presidency of the Royal Society. Two decades passed away before the precedent was followed, and at the present time only one member of the medical profession is a member of the House of Lords—Lord Dawson of Penn. Many congratulatory speeches were made and numerous public receptions and banquets were held to celebrate Lister's new honour, the most interesting of all, perhaps, to "the Chief" being a banquet given by his old house surgeons, clerks, and dressers, in May 1897. Those present numbered a hundred and thirty, but there were many others who were unable to attend. Numbers of them had achieved

to distinction and honour and had made contributions of great importance to Science and Medicine, and all had gathered together from near and far to pay tribute to the man who had inspired them in their youthful days through his eager search for truth and his efforts for the good of his fellow creatures. The gathering manifested its feelings with even more than the usual enthusiasm that is customary on such occasions; but for the guest of honour the banquet brought a reminder that his active life was nearly over. It is not surprising, therefore, that " there were obvious signs of emotion in the short and feeling speech in which Lister acknowledged the toast of his health."

When King Edward was seized with a serious illness shortly before the date fixed for his Coronation in 1902, Lister was one of those whose advice was sought, and he was present at the consultation on June 24, before the operation performed by Sir Frederick Treves. At the Coronation the following year King Edward instituted the new Order of Merit to be conferred as a special distinction upon eminent men. This Order is limited to twenty-four. Lister was one of the first twelve admitted to the Order, and about the same time he was sworn a Member of the Privy Council.

This year the *British Medical Journal* brought out a special " Lister Number " to commemorate December 9, 1902, the fiftieth anniversary of the day on which Lister was made a Fellow of the Royal College of Surgeons. Some of the con-

tributors of the articles contained therein were men who had taken a great part in the battle for antisepsis in the past, and the number included a bibliography of Lister's writings. There was also a long editorial speaking of the far-reaching effects of his work upon modern medicine and surgery.

When, for the first time in history, the Senate of the London University, setting aside its ancient custom, decided to confer certain honorary degrees, Lord Lister was chosen as one of the recipients, the others being the Prince and Princess of Wales, and Lord Kelvin. In his speech, at the Albert Hall on Presentation Day 1903, wherein he referred to Lister and Kelvin as the two " Princes of Science," the Chancellor, Lord Rosebery, said that having once exercised their prerogative of granting honorary degrees, the Senate would be parsimonious in the future. He added, " I hope with all my heart, and I believe in that opinion I voice the judgment of the Senate—I hope this will not be an annual celebration; that it will not be the task of the University, at recurring periods, to find persons worthy to receive their honorary degree, and that it shall only be persons worthy to stand on the same plane with our doctors of to-night whom we shall ever summon to this dais to receive that degree in future."

A month afterwards Lister was seized with a serious illness, something like a slight paralytic stroke, whilst spending a holiday at Buxton. For some time he was unable to walk properly,

mental efforts were impossible, and his appearance at the family Christmas gathering was out of the question for the first time in many years. The remaining nine years of his life were passed in retirement, partly in London and partly in the country, enlivened from time to time by the visits of nephews, nieces, and other relatives and friends. His mental capacities were restored and his walking powers returned, but though he continued to study English and foreign scientific literature and kept up correspondence with the outside world, he more and more complained of his weakness and inability to concentrate upon intellectual problems. One of his griefs at this time was the fact that he felt himself incapable of arranging and editing the works of his lifetime. Lister never wrote a book, because he never had the inclination for such an undertaking, except once in his life, and that at a time when the pressure of everyday affairs made it impossible. When the days of leisure arrived the death of Lady Lister banished the idea from his mind for many years; had she been there, how she would have enjoyed her share in it! Now it was too late. As his eightieth birthday approached, however, it was felt by many that the best way of commemorating it would be to collect all his works from the various journals and transactions in which they were hidden and present them to Lister in book form. The suggestion originally came from Dr. C. J. Martin, who, together with Dr. (now Sir) Dawson Williams, editor of the *British Medical Journal*,

Sir Hector Cameron and Sir Watson Cheyne, former house surgeons to Lister, and Sir Rickman J. Godlee, his nephew, formed a Committee which was elected at a large meeting held in the College of Surgeons, to carry out the project. It was very successfully performed, and the considerable labour involved was fully repaid by the pleasure it gave to Lister. The two large handsome quarto volumes entitled "The Collected Papers of Joseph, Baron Lister," with their bold type and beautiful reproductions of his drawings, form the finest monument that could have been erected to his memory. The contents are arranged in five parts: viz. (1) Physiology; (2) Pathology and Bacteriology; (3) The Antiseptic System; (4) Surgery; (5) Addresses. In addition to their interest for the historian, Lister's papers might be studied with great profit by those who would devote themselves to experimental work. This scientific sceptic never accepted any tradition, however sacred, without satisfying himself that it rested upon sound evidence; and throughout his papers he shows himself to have been an inductive philosopher with a genius for seeing at once the precise experiment necessary to clear up a doubtful point.

Lister's eightieth birthday was commemorated by the world generally in enthusiastic style. Telegraph boys and messengers bearing bouquets of flowers kept the porter busy opening the door the whole day long. Eminent men, British and foreign, waited upon him personally as heads of deputations that had come to offer their felicita-

tions. Almost every paper in the kingdom had a eulogistic article and a photograph, the foreign papers were not far behind, and in Berlin, where the German Surgical Society was in session, the surgeons celebrated the day in their own fashion. One may, perhaps, be allowed to guess what were the thoughts of Lister as the lonely and feeble old man listened to the congratulations of his friends and the words of adulation from the deputations that waited upon him. Writing to his brother ten days later he said, "What a change of opinion has taken place during the years that I have been doing nothing!"

Almost too late there came the bestowal of an honour that more graciously could have been conferred upon him many years before. This was the Freedom of the City of Glasgow, which was accepted on his behalf by Sir Hector Cameron, on January 22nd, 1908, Lister then being too broken down in health to take the necessary journey. Though Lister himself had no such feeling, and, indeed, always seemed surprised when any great honour was paid to him, yet his friends felt that Glasgow had been a very long time in forgiving him for his publication concerning the insalubrious atmosphere of her Royal Infirmary at the time of his discovery of the Antiseptic System. But, as Sir Hector Cameron said, "There was a certain dramatic completeness in the fact that Glasgow should, in the end of his career, make her contribution to that crown of honour which would for all time sit upon his brow."

This great and noble man passed away almost imperceptibly on February 10, 1912, after a gradual ebbing away of mental and physical powers. Like a tired child he quietly fell asleep. It was expected that he would be buried in Westminster Abbey, but Lister had left instructions that he was to be placed to rest by the side of his wife. On February 16 a public funeral service was held in the Abbey, at which were present representatives of Royal Personages, the Diplomatic Corps, Ministers of State, civic dignitaries, and delegates from Universities and medical and scientific societies, British and foreign. Many had come from near continental countries to pay their last tribute to his memory. The congregation was a large one, consisting of members of his own profession, men of science, old patients, old friends, and many others who only knew of him through his work. After the Abbey service Lister was accompanied to his last home in West Hampstead Cemetery by his most intimate friends, and there a simple tombstone marks the spot where he and Lady Lister lie side by side.

PRINCIPAL DATES

Joseph Lister. Born at Upton, Essex, April 5th, 1827.
Student at University College, London, 1844.
Graduated M.B. (London) and F.R.C.S. (England), 1852.
First microscopical and experimental work, 1853.
Syme's house surgeon at Edinburgh, 1854.
Engagement to Agnes Syme, 1855.
Marriage to Agnes Syme, 1856.
Assistant Surgeon to Edinburgh Royal Infirmary, 1856.
Paper on Early Stages of Inflammation, 1857.
Appointed Professor of Surgery at Glasgow, 1860.
Surgeon to Glasgow Royal Infirmary, 1861.
Studied writings of Louis Pasteur, 1865.
Beginning of Antiseptic System, 1865.
First paper published on Antiseptic System, 1867.
Professor of Clinical Surgery at Edinburgh, 1869.
Surgeon-in-Ordinary to Queen Victoria (in Scotland), 1870.
General Medical Council, 1876.
Fiftieth birthday, 1877.
Professor of Clinical Surgery at King's College, London, 1877.
Baronetcy, 1883.
Retirement from Professorship at King's College, 1892.
Retirement from King's College Hospital, 1893.
Death of Lady Lister, 1893.
President of Royal Society, 1895.
Peerage, 1897.
Order of Merit, 1902.
Privy Councillor, 1902.
Freedom of the City of Glasgow, 1908.
Death, February 10th, 1912.

BOOKS RECOMMENDED

"The Collected Papers of Joseph, Baron Lister." Vols. I and II. (Henry Frowde. Oxford University Press.)

"Lord Lister," by Sir Rickman John Godlee, Bt. 1918. (Macmillan & Co.)

"The Works of Sir James Y. Simpson, Bart." 1871. (Adam and Black, Edinburgh.)

British Medical Journal, December 9, 1902. (Lister Number.) (See also bound volumes of *British Medical Journal* and *Lancet* from 1865 to 1912.)

"Semmelweis: his Life and Doctrine." Sir William Sinclair. 1909. (Manchester Univ. Press.)

"The Life of Pasteur," by R. Vallery-Radot. 1919. (Richard Clay & Sons.)

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